PROCEEDINGS

OF THE

BELFAST

Natural History and Philosophical Society,

FOR THE

SESSION 1880–81.

BELFAST:
PRINTED BY ALEXANDER MAYNE, CORPORATION STREET.
(PRINTER TO THE QUEEN'S COLLEGE.)

1882.

PROCEEDINGS

OF THE

BELFAST

Natural History and Philosophical Society,

FOR THE

SESSION 1880–81.

BELFAST:
PRINTED BY ALEXANDER MAYNE, CORPORATION STREET.
(PRINTER TO THE QUEEN'S COLLEGE.)

1882.

ERRATUM.—Page 37, line 16, for *grape* sugar read *cane* sugar.

CONTENTS.

Belfast Natural History and Philosophical Society.

ESTABLISHED 1821.

SHAREHOLDERS.

1 Share in the Society costs £7.
2 Shares ,, ,, cost £14.
3 Shares ,, ,, cost £21.

The proprietor of 1 Share pays 10s. per annum; the proprietor of 2 Shares pays 5s. per annum; the proprietor of three or more Shares stands exempt from further payment.

Shareholders only are eligible for election on the Council of Management.

MEMBERS.

There are two classes, Ordinary Members, who are expected to read Papers, and Visiting Members, who, by joining under the latter title, are understood to intimate that they do not wish to read Papers. The Session for Lectures extends from November in one year till May in the succeeding one. Members, Ordinary or Visiting, pay £1 1s. per annum, due first November in each year.

PRIVILEGES.

Each Shareholder and Member has the right of personal attendance at all meetings of the Society, and of admitting a friend thereto; also of access to the Museum for himself and family, with the privilege of granting admission orders for inspecting the collections to any friends not residing in Belfast.

Any further information can be obtained by application to the Secretary. It is requested that all accounts due by the Society be sent to the Treasurer.

The Museum, College Square North, is open daily from 12 till 4 o'clock. Admission for strangers, 6d. Each. The Curator is in constant attendance, and will take charge of any Donation kindly left for the Museum or Library.

BELFAST
NATURAL HISTORY & PHILOSOPHICAL SOCIETY.

Officers and Council of Management for 1881-82.

SHAREHOLDERS.

[**Denotes holders of three or more Shares.*]

Allen, W. J. C., J.P., Faunoran, Greenisland.
Andrews, James (Representatives of), Donegall Street, Belfast.
Andrews, Michael (Representatives of), Ardoyne, do.
Andrews, Thomas, M.D., F.R.S., &c., Queen's College, do.
Andrews, Samuel, J.P., Victoria Street do.
Archer, S., J.P. (Representatives of), Wellington Place, do.
Anderson, John, J.P., F.G.S., Hillbrook, Holywood.
*Alexander, James, J.P. (Representatives of), Holywood.

*Bateson, Sir Thomas, Bart., M.P., J.P., D.L., Belvoir Park, Belfast.

*Batt, Thomas G. (Representatives of), Belfast.
Bland, Rev. W., J.P. (Representatives of), Whiteabbey.
Bottomley, Henry H., Ulster Street, Belfast.

*Bottomley, William, J.P., Calender Street, Belfast.
Brett, C. H., Chichester Street, do.
Bristow, James R., Northern Bank, do.
Barbour, James, Falls Foundry, do.
Boyd, William, Blackstaff Mill, do.
Boyd, W. S., Donegall Quay, do.
Brown, John Shaw, Bedford Street, do.
Brown, John, Bedford Street, do.
Burden, Henry, M.D., College Square North, do.
Burnett, John R., Gamble Street, do.

*Campbell, James (Representatives of), Cultra, Co. Down.
Campbell, John, Copeland View, Greenisland.
Connor, Charles C., White Linen Hall, Belfast.
Carlisle, James, J.P., Donegall Street, do.
Carson, John, Church Lane, do.
Charley, John (Representatives of), College Park, do.
*Charley, John (Representatives of), Finaghy, do.
*Clermont, Lord, Ravensdale Park, Newry.
Coates, Victor, Rathmore, Dunmurry.
Corbett, Mrs. Clarendon Place, Belfast.
*Charters, John (Representatives of), Craigowen, Craigavad.
Crawford, William, Donegall Place, Belfast.
Cuming, James, M.D., Wellington Place, do.
Combe, James, J.P. (Representatives of), Ormiston, Sydenham.
Connor, James (Reps. of), Great George's Street, Belfast.
Calwell, Alexander McD., College Square North, do.
Cunningham, Robert O., M.D., F.L.S., Queen's College, do.
Clarke, Edward H., Belfast Bank, do.

Darbishire, James M., Lombard Street, do.
*Donegall, Marquis of, K.P., &c., &c., London.
Drennan, Dr., Chichester Street, Belfast.
*Drummond, Dr. James L. (Representatives of), do.
Duffin, Charles, J.P., Waring Street, do.
Dunville, William, J.P. (Representatives of), Calender St., do.
*Downshire, Marquis of, Hillsborough Castle, Hillsborough.
Dixon, Thomas S., York Street, Belfast.

Emerson, William, Donegall Quay,	Belfast.
Everett, Joseph David, M.A., D.C.L., Queen's College,	do.
Ewart, William, J.P., M.P., Bedford Street,	do.
Ewart, W. Quartus, Bedford Street,	do.
*Fenton, Samuel G., J.P., (Representatives of),	do.
Ferguson, Henry, M.D., Fisherwick Place,	do.
Forsythe, R. H., Holywood.	
Finlay, William Laird, Windsor,	Belfast.
Finlay, Charles, J.P. (Representatives of), University Sq.,	do.
Fuller, Professor George, Queen's College,	do.
Fagan, John, F.R.C.S.I., University Road,	do.
Garrett, Thomas, Gamble Street,	do.
*Getty, Edmund (Representatives of),	do.
Girdwood, H. Mercer, Bath Place Mill,	do.
Gordon, Alexander, M.D., Howard Street,	do.
Gordon, R. F., J.P., D.L., Florida Manor, Killinchy.	
*Grainger, Rev. John, D.D., Broughshane, Ballymena.	
Gray, Robert (Representatives of), College Square East,	Belfast.
Gordon, Robert W., Falls Road,	do.
Greer, Thomas, J.P., M.P., Sea Park, Carrickfergus.	
Gray, William, C.E., M.R.I.A., Mount Charles,	Belfast.
Hogg, John, Academy Street,	do.
Hind, John, jun., College Street South,	do.
*Hamilton, Hill, J.P. (Representatives of), Mount Vernon,	do.
Hancock, John, J.P., Lurgan.	
Henderson, Robert (Representatives of), Queen's Square,	Belfast.
*Henry, Alexander, Manchester.	
*Herdman, John (Representatives of), College Sq. North,	Belfast.
Hind, James, Durham Street,	do.
Hind, John, J.P., Durham Street,	do.
Heyn, James, A.M., Ulster Chambers, Waring Street,	do.
*Houston, John B., J.P., D.L., Orangefield,	do.
Herdman, John, Carricklee House, Strabane.	
Hamilton, Sir James, J.P., Corporation Street,	Belfast.
Harland, Edward J., J.P., Queen's Island,	do.
Hodges, John F., M.D., F.C.S., Queen's College,	do.

Hyndman, Hugh, LL.B., Waring Street, Belfast.
Henderson, W. D., Victoria Street, do.
Henderson, James Alexander, J.P., Donegall Street, do.
Holford, T. & A., Dorsetshire (Cern Abbas).

Jackson, Thomas, C.E., Corn Market, Belfast.
Jackson, W. R., Corn Market, do.
Jaffé, John, Donegall Square South, do.
Jaffé, Otto, Donegall Square South, do.
*Johnson, Sir William G., J.P., D.L., College Sq. North, do.
Johnston, Samuel A., Jennymount Mill, do.
Johnston, David W., Jennymount Mill, do.

Kennedy, James, Falls Road, do.
Keegan, James, J.P., High Street, do.
*Kinghan, Rev. John, Deaf and Dumb Institution, do.

Lanyon, Sir Charles, J.P., The Abbey, Whiteabbey.
Lepper, F. R., Ulster Bank, Belfast.
Lakin, Mrs. John, Tamworth.
Lamb, William W., Divis View, Belfast.
Letts, Professor E. A., Queen's College, do.
Lytle, David B., Victoria Street, do.

*Macrory, Adam J. (Representatives of), Duncairn, do.
Mitchell, W. C., J.P., Tomb Street, do.
*Mitchell, George T. (Representatives of), do.
Montgomery, Thomas, J.P., Ballydrain, do.
Moore, James, J.P., Dalchoolin, Craigavad.
*Mulholland, Andrew, J.P., D.L. (Representatives of), Belfast.
Mulholland, J., J.P., D.L., M.P., Ballywalter Park, Ballywalter.
Mullan, William, J.P., Victoria Street, Belfast.
Murney, Henry, J.P., M.D., Donegall Square East, do.
Musgrave, James, J.P., Ann Street, do.
Murray, Robert (Representatives of), Arthur Street, do.
*Murphy, Joseph John, F.G.S., Old Forge, Dunmurry.
*Murphy, Isaac James, Glenburn, do.
Musgrave, Henry, Ann Street, Belfast.
Musgrave, Edgar, Ann Street, do.
Moore, James, Donegall Place, do.

MacIlwaine, Mrs. Jane, Belfast.
MacIlwaine, Rev. Canon, D.D., M.R.I.A., Netherville Terrace, Belfast.
MacAdam, Robert, College Square East, Belfast.
*M'Calmont, Robert, London.
*M'Cammon, Thomas, Dublin.
*M'Cance, J. W. S., (Representatives of), Suffolk, Dunmurry.
M'Clure, Sir Thomas, Bart., V.L., J.P., Belmont, Belfast.
*M'Cracken, Francis (Representatives of), Donegall St., do.
M'Cance, Finlay, J.P., Suffolk, Dunmurry.
*MacLaine, Alex., Corporation Street and Queen's Elms, Belfast.
M'Gee, John G., High Street, do.

Neill, John R., Queen's Arcade, do.

Patterson, E. Forbes, High Street, do.
Patterson, Mrs. M. E., College Square North, do.
Pim, Edward W., High Street, do.
Pim, George, Corporation Street, do.
*Pirrie, John M., M.D. (Representatives of), Fisherwick Pl. do.
Purdon, Charles D., M.D. (Reps. of), Wellington Place, do.
Purdon, Thomas Henry, M.D., do. do.
Patterson, William R., Lower Crescent, do.
Patterson, R. Lloyd, Corporation Street, do.
Patterson, William H., M.R.I.A., High Street, do.
Purser, Professor John, M.A., Queen's College, do.
Porter, Rev. J. Scott (Representatives of), Lennoxvale, do.
Patterson, Richard, High Street, do.
Patterson, David C., Corporation Street, do.

Riddel, William, Ann Street, do.
Rowan, John, York Street, do.
Ritchie, W. B., M.D., J.P., The Grove, do.
Ross, William A., J.P., Clonard, Falls Road do.
Rea, John Henry, M.D., Great Victoria Street, do.
Robertson, William, J.P., Bank Buildings, do.
Robinson, John, York Street, do.

Simms, William, White Linen Hall, do.
Sinclair, Thomas, M.A., J.P., Tomb Street, do.

Suffern, John, Windsor,	Belfast.
Suffern, William, Windsor,	do.
Steen, Dr. Robert, Ph.D., Academical Institution	do.
Smyth, John, jun., M.A., C.E., Milltown, Banbridge,	
Smith, F. Chaloner, Sandymount.	
Swanston, William, F.G.S., King Street,	Belfast.
*Tennent, R. J., J.P., D.L. (Representatives of), Rushpark,	do.
*Tennent, Robert (Representatives of), Rushpark,	do.
Thompson, Robert, J.P., Donegall Square North,	do.
Thomson, Charles, Fountainville,	do.
*Thompson, James, J.P., Macedon, Whiteabbey.	
*Thompson, Nathaniel (Representatives of), Holywood.	
Thomson, Professor James, LL.D., Glasgow.	
*Thompson, William (Representatives of),	Belfast.
*Turnley, John (Representatives of),	do.
Torrens, James, J.P., Wellington Place,	do.
Valentine, James W., Whiteabbey,	do.
Valentine, Thomas, J.P., The Moat, Strandtown,	do.
Walkington, Thomas, Waring Street,	do
Workman, William, Corporation Street,	do.
Workman, Rev. R., Newtownbreda.	
Wilson, John K., Donegall Street,	Belfast.
*Wilson, Robert M.	
*Workman, Thomas, Bedford Street,	Belfast.
Wallace, James, Ulster Bank,	do.
Ward, Fras. D., J.P., Bankmore,	do.
Wright, Joseph, F.G.S., Donegall Street,	do.
Workman, Charles, M.D., Balmoral Terrace,	do.
Workman, Rev. R., Glastry, Kirkcubbin.	
Walkington, D. B., Windsor.	
Young, Robert, C.E., Donegall Square East,	Belfast.
Young, Robert M., Donegall Square East,	do.

HONORARY MEMBERS.

Stewart, Samuel A., F.L.S., North Street,	Belfast.
Robinson, Hugh, Donegall Street,	do
Tate, Professor Ralph, F.G.S., Adelaide, South Australia.	

ANNUAL GUINEA SUBSCRIBERS.

Barbour, J., County Down Railway,	Belfast.
Bruce, James, Calender Street	do
Bulloch A., Donegall Square South,	do
Corry, James P., J.P., M.P., Dunraven, Windsor,	do
Craig, James, Calender Street,	do
Corry, Thomas H., Benvue, Malone,	do
Collier, Dr., The Academy, Cliftonville,	do
Carr, James, Ulster Bank,	do
Cramsie, John, J.P., Waring Street,	do
Dinnen, John, Chichester Street,	do
Dunville, Robert G., J.P., Calender Street,	do
Glass, James, Bedford Street,	do
Glover, G. T., Ballymacarrett	do
Graham, O. B., J.P., York Street,	do
Liversedge, H. J., Lagan Foundry	do
Loewenthal J., Linenhall Street,	do
Lynn, William, C.E., Calender Street,	do
Matier, Henry, J.P., Clarence Place,	do
Mulholland, J. R. T., J.P.	do
M'Auliffe, George, J.P., Calender Street,	do
Oakman, Nicholas, Prospect Terrace,	do
Pring, Richard W., Corn Market,	do
Porter, Robert, York Street,	do
Redfern, Peter, M.D., Prof. Queen's College,	do
Reade, Robert H., York Street,	do
Seeds, William, Arthur Street,	do
Taylor, David, J.P., Windsor,	do
Tate, Alexander, C.E., Queen's Elms,	do
Taylor, John Arnott, M.A., Bridge Street,	do
Watt, R., Donegall Place,	do
Wolff, J. W., Queen's Island,	do
Wilson, James, Skipper Street,	do
Ward, John, F.G.S., Lennoxvale,	do
Ward, Marcus J., Bankmore,	do

The Belfast Natural History and Philosophical Society, for the Year ending 1st May, 1881, in Account with Treasurer.

Dr. | Cr.

Date	EXPENDITURE.	£	s.	d.
1880.				
July 14—	To Cash paid Mayne, Printer ...	£46	13	6
Nov. 2—	,, ,, Repairs, Dwelling-house	9	15	0
1881.				
Feb. 1—	,, ,, Rent, Premises, till 1st May, 1881	25	0	0
,,	,, ,, Cretaceous Fossils (Galt)	2	0	0
,,	,, ,, Insurances	9	19	6
,,	,, ,, Mr. Darragh, Salary till 1st May	68	5	0
,,	,, ,, Mr. Stewart, Salary till 1st April	12	10	0
,,	,, ,, Advertisements—*Whig*, £10 1s 5d; *News-Letter*, £6 12s 11d	16	14	4
,,	,, ,, Archer, £2 10s; Ward, 4/6	2	14	6
,,	,, ,, Sundry Accounts, paid through Mr. Darragh (including Coals, £13 15s 0d; Gas, £1 10s 10d; Collecting Subscriptions, £5 19s 5d; Extra Expenses, £8 3s 2d, &c.) ...	36	19	4
,,	To Balance in Treasurer's hands ...	38	3	10
		£268	15	0

Date	RECEIPTS.	£	s.	d.
1880.				
June 1—	By Balance in hands	£23	14	6
Aug. 16—	,, Dividend, N. C. Railway ...	8	15	10
1881.				
Jan. 18—	,, Profit in Re-investing £400 ...	43	15	3
,, 27—	,, Engineers' Association Contribution	4	3	0
April 30—	,, Subscriptions for Year ending Nov., 1880	79	13	0
,,	,, Naturalists' Field Club Contribution	5	5	0
,,	,, Proceeds—Easter Monday ...	29	6	8
,,	,, Visitors, at door...	14	11	6
,,	,, Balance, Building Fund, through Treasurer	59	10	3
		£268	15	0
1881.				
1st May—	By Balance	£38	3	10

Examined and found correct,
4th June, 1881.

W. H. PATTERSON,
W. D. HENDERSON, } *Auditors.*

JOHN ANDERSON, *Hon. Treasurer.*

BELFAST

NATURAL HISTORY & PHILOSOPHICAL SOCIETY,

SESSION 1880–81.

2nd November, 1880.

Professor PURSER, President, in the Chair.

Mr. WILLIAM H. PATTERSON, M.R.I.A., gave a description of

THE BENN COLLECTION OF ANTIQUITIES.

THE PRESIDENT said they met that evening to open the sixtieth session of that Society. It had been for many years the custom of the President to give at the opening meeting an inaugural address in the form of an account of recent researches in science. On the present occasion they proposed to deviate from that course, and the Council of the Society had sanctioned an arrangement which, he had no doubt, would be very much pleasanter to the audience, and certainly, with the present College engagement, which he had at the beginning of the session, more convenient to himself; and that arrangement was that they should, on the present occasion, hear from one of their members a description of the valuable collection of antiquities and archæological specimens which had been presented to them by Mr. George Benn. The member of this Society who was about to give them this description was Mr. William H. Patterson, who, as they all knew, was admirably qualified for the task; and he (the President) was quite sure they would spend a most interesting evening. Since he had the honour of addressing them at the opening meeting last November, the Society had been enriched by two most valuable gifts. Mr. George Benn, known to them all as the historian of this town, had given to the Society the collection of anti-

quities which, through many years' patient research, had been made by his late brother, Mr. Edward Benn, with this proviso, that the Society would furnish a suitable habitat for the collection. The Committee of the Society, with very great spirit, met Mr. Benn's liberality by collecting from their townsmen a considerable sum of money, some £400 or £500 ; and the fruits of that amount they had in the building that evening. They had now got added to the edifice three valuable rooms. One of them was devoted to Mr. Benn's collection ; in the second, their librarian proposed to deposit the very valuable assortment of books. That assortment contained a tolerably complete set of the transactions of learned societies. Many of the learned societies of Europe presented to that Society copies of their transactions. The third room, which was a smaller one, was exceedingly well adapted for the holding of committee meetings, and for such like purposes. Before he made way for Mr. Patterson, he would just say how anxious the Council were that more of those who were members of the Society and who attended its meetings would come forward and give them, in the shape of papers or short addresses, the result of their labours. One of these they had last year, and it was highly appreciated. He hoped that the example thus set would be imitated by others during the coming session. Mr. Patterson would now proceed with his address.

Mr. Patterson said : Mr. President, ladies and gentlemen, most of you are aware that in the early part of this year the large collection of antiquities which had been formed by the late Mr. Edward Benn, of Glenravel House, County of Antrim, was presented to this Society by his brother, Mr. George Benn, to whom the collection had been bequeathed. You are also, no doubt, aware that the Council of the Society, with a view of securing a suitable abiding-place for this important collection of the antiquities of our country, determined upon building an addition to the Museum which would accommodate the Benn collection, and, at the same time, would afford some very essential accommodation for other portions of their collections

which had never been adequately displayed. The Council set to work to collect the necessary funds, and, by the kindness of friends, they were shortly enabled to commence the building of the three-storeyed addition which you now have the opportunity of seeing. The contractor did his work in a rapid and satisfactory manner, under the superintendence of our fellow-member, Mr. Young, who, I should say, was President of our Society at the time this work was commenced. The lower room of the new building, in which the Benn collection is deposited, was formally opened in July last, on the occasion of the meeting being held here of the Royal Archæological and Historical Association of Ireland, Mr. Young having in a few appropriate words declared the Benn collection open. At the same time, the remainder of the space in the room not already occupied by the Benn collection was filled with a most interesting collection of antiquities, chiefly stone implements, Irish and American, which were lent to the Committee of the Archæological Association by a small number of friends residing in the neighbourhood, who are the fortunate possessors of very fine collections. This loan collection is only mentioned incidentally ; but, having named it, I should like just to say further, that among those who contributed towards the collection were Messrs. Gray, Knowles, Raphael, O'Laverty, Canon MacIlwaine, Canon Grainger, and the Earl of Antrim. I should also specially mention Mr. Gray's series of coloured drawings of cromlechs and other rude stone monuments and remains existing in this neighbourhood. This series is most interesting, and quite unique.

I have been asked to give this evening some account or description of the Benn collection, by way, perhaps, of introducing it more particularly to the notice of the members of this Society and their friends. I have already mentioned briefly how and when the collection came into the possession of our Society, and now it will be well to mention more particularly the classes of objects and the numbers of objects in each class, so that you may have an idea of the extent of the collection. But first let me say that the late Mr. Benn had exceptionally

good opportunities for forming a collection of Irish antiquities. The possessor of ample means, he lived for many years in a district which is probably the richest in Ireland in stone implements. Living not in a town, but in the centre of a wide country district, he became known far and near as a purchaser of anything curious which might be found from time to time in the bogs or in the operations of the farm, in reclaiming and breaking up waste lands, and in sinking drains, clearing out water-courses, and all the other ways in which lost and buried objects come to light. It may not be generally known that the chief friends of collectors of antiquities are ragmen. These men, in wandering all over the country, have opportunities of getting possession of things that have been found ; and, when they know that certain things are in demand, they inquire for them, and it is wonderful what numbers of things they pick up—in this cottage a flint arrow head or a stone axe, in that a bronze spear head or celt, and in another a quern stone or an enamelled bead or old coin. These things are carefully stored away for days and weeks, as the case may be, till the ragman's wanderings bring him near the house of the collector, whom he has had in view all the time, as the person who will give him shillings for what he has only paid pence ; and the collector is glad to get an addition to his cabinet, and dismisses the ragman with an admonition to bring him the next curious things he finds. A blessing on the ragmen! But for their intervention, most of the antiques that are dug up would soon be lost again ; unless of metal, the labourer who found an implement would likely throw it away, or, if he brought it home, it would become the plaything of the children for a short time, and then would be either broken or lost. But for the ragman, most of the collections of Irish antiquities would be much smaller than they are. The ragmen are not absolutely truthful ; and, if they find that it will enhance the value of any antique they have to sell, they will not hesitate to invent a story, as to how it was found in an old rath, or fort, or castle. Some of them also try their hand, but in a very clumsy way, at the forging of antiquities, but these forgeries are so bare-

faced that it is seldom hard to detect them. Our wandering dealers lack the manipulative skill of the celebrated "Flint Jack." Collectors tell me that when a man has brought them some good things, and perhaps is likely to bring them more, they sometimes take from him these forgeries, or duplicate specimens, which they in no way require, in order to encourage the ragman to come back, and also as a bribe to prevent him taking his finds to some rival collector; for I may tell you it is one of the special peculiarities of collectors to be very jealous of other collectors. A collector wants to have things that no other collector has; hence these forgeries and impostures are winked at.

Mr. Benn's collection was especially rich in stone implements, and this is just what might be expected in a collection formed in the County of Antrim. The County Antrim flint must have been of immense importance to the inhabitants of this country, from the very earliest coming of primitive man down to the discovery or introduction of metals; and no doubt our flint formed an article of barter with the inhabitants of other districts of the country, because, with the exception of a part of Derry, no flint is found elsewhere in Ireland. It has been more than once pointed out by readers of papers here that regular manufactories of flint implements existed in very old times in different parts of Antrim, usually near places where the chalk rocks came to the surface.

I will now give an enumeration of the various objects that compose the Benn collection as at present displayed:—Of polished stone celts there are 94; flint celts, partly polished, 8; finely worked flint arrow heads, lozenge-shaped, barbed and stemmed, and lance heads, 228; flint flakes, worked, 34; thumb flints, or scrapers, 18. Of the class of objects known as hammer stones, some of which are oval, some oblong, some perforated, and some not, there are, including some that may have been spindle steps, about 100. Of small stone disks, perforated by a central hole, which were probably worn as personal ornaments, or as charms, or armlets, or which may have been spindle whorls, and are called in some parts of Ireland "fairy mill-

stones," there are about 200. There are also several querns and grain rubbers, making in all, of stone objects, a total of upwards of 872.

The next objects which I will direct your attention to are those formed of earthen and glass materials, and these are extremely interesting, as they comprise the glass beads, of which there is a very fine series, and also the cinerary urns. The beads in the collection, including those of amber, number about 400. Some of these are probably not ancient; but of undoubtedly ancient beads, both plain and enamelled with several colours of glass, there are a great many. Some of them, as might be expected, are quite unique, and it is remarkable how closely they resemble the beads found in so-called Saxon tombs in England, as drawn and coloured in a work on the Faussett collection, compiled by the late Mr. Joseph Mayer. Many of you will remember the fine series of ancient beads that was exhibited here lately by Mr. Knowles, of Cullybackey; and in considering the great number of beautiful and elaborately ornamented beads in Mr. Knowles's, in Mr. Benn's, and in other local collections, one cannot help being struck with the immense numbers of these fine ornaments which the ancient people here possessed. I would like you to examine these beads when you have opportunities of doing so, and I feel sure you will be struck by the skill with which they are made, and by the taste displayed in harmonising the various colours of the enamel. One reason, no doubt, why so many of these beads have been found in such a perfect state is the comparative indestructibility of glass when buried in the ground. Some of the beads may have formed the heads of pins of either wood, bone, or bronze, the pin part having long since mouldered away. It is possible that these beautiful beads may not have been made in Ireland at all, but may be of Continental, possibly Italian, workmanship. Very similar beads have been found in England and Scotland, and also in Denmark and about the Swiss lake dwellings. Mr. Day, in a paper on enamelled beads in his possession, communicated to the Kilkenny Archæological

Association in 1869, says:—"I would be led to suppose . . . . that these beads were imported, and that they may be classed with the antiquities which belong to the late bronze and early iron period. When found by the peasantry, they are still regarded as possessing a talismanic power, and are sometimes called *gloine-an-drudgh*, or 'the magician's glass,' and in Scotland they are called 'adder stones' and 'snake stones.'" In speaking of the colours of these beads, Mr. Day writes:—"Blue appears to have been the favourite colour, but, while that is so, our museums and private collections can show others in pale green, white, yellow, and red, and with spirals and other ornaments of varied colours; while others have a dark groundwork, and are studded with fragments of red, green, yellow, blue, and white enamel, which are set without any attempt at order on the surface. There is one form of glass ornaments which, so far as I can ascertain, is only found in Ireland; it is shaped somewhat like a dumb-bell, and is made of green vitrified porcelain or opaque glass." Some of these small double-headed beads are in the Benn collection. I am aware that Mr. Edward Benn considered his collection of beads very important, and that he communicated a paper upon them to the Historical Society of Lancashire and Cheshire, which was published in their transactions. There are several fine cinerary urns in the collection, but, unfortunately, most of them are more or less broken, while some consist of mere fragments. These urns contained the ashes of individuals of a race which practised cremation, that extremely satisfactory way of disposing of the remains of the dead, to which ancient practice there now seems a disposition to return. Such urns have frequently been found in Ireland, and in England and Scotland. They are filled with fragments of charred bones, and are generally discovered with the mouth or open downwards, resting on a slate or small slab, and surrounded by a rudely-built chamber of stones. One of the urns in this collection was found in a sand-hill near Dervock, County of Antrim; another one was found at Belsallagh, parish of Skerry, County of Antrim, in 1834; and another larger one is

labelled as having been found in the townland of Legagrane, parish of Dunaghy. Several small crucibles, which have evidently been used, are in the collection. Such crucibles are occasionally found about the crannogs or lake dwellings, and were, no doubt, used for melting the gold, bronze, and *findrinné*, or white bronze, of which the ancient inhabitants of the country formed the beautiful personal ornaments and weapons which are so familiar to us. The finding of these worn crucibles proves that metal work was carried on in the districts where they are found. The last objects which may be enumerated as coming under the class of earthen materials are some of those small clay tobacco pipes which are found in many places, generally about towns or places which were centres of population a couple of hundred years ago. The peasantry call these Danes' pipes, from the fondness they have of attributing everything ancient that they do not understand to the Danes; or sometimes, by calling them fairy pipes, they attribute a supernatural origin to them. In reality, however, they have a much later and more prosaic origin, as they were just the ordinary smoking pipes of about two hundred years ago. They are often found in street cuttings for sewers, associated with copper coins of the Williamite period, and many of them are stamped with initials or other trade marks, which are known to have been used by pipe makers who lived at Broseley and other places in England. Of these pipes there are seven. There are also some objects of jet which are curious.

This, I think, exhausts the articles that are formed of glass or earthen materials, and I therefore pass on to a more interesting class of objects—namely, those of bronze. These are more interesting, because they show an entirely fresh departure in human culture. Hitherto I have spoken of axes and lance heads formed of stone; now we find them formed of a hard and handsome metal, taking a keen edge, many of them carefully and thoughtfully ornamented with patterns formed by incised lines or dots, the very kind of ornament that was most suitable to the material and the objects. You can well imagine how soon a race of people armed only with stone would go down

before a race armed with bronze weapons. They would be either exterminated or enslaved. The division of pre-historic time into a stone, a bronze, and an iron age, as far as regards man's advancement in civilisation, is an extremely simple, and at the same time an ingenious one. You are aware that this division was first suggested and adopted by the Danish archæologists, and was founded on the results of their investigations in the peat bogs of Denmark. They found that low down in the peat the only implements or objects of man's workmanship were formed of stone; then, at a higher level in the peat, weapons of bronze were found associated with stone. As the explorers examined higher beds, they found that bronze increased in quantity, while stone diminished; and, passing still upwards, when the maximum of bronze implements and weapons had been attained, iron began to make its appearance as the material of which weapons, &c., were formed; and, passing still nearer the surface, as bronze decreased so iron increased, until the iron age was fairly entered on. Sir John Lubbock divides pre-historic archæology into four great epochs. This is done by making two stone periods—that is, an earlier and a later. The following are the divisions he adopts:—

"I. That of the drift, when man shared the possession of Europe with the mammoth, the cave-bear, the woolly-haired rhinoceros, and other extinct animals. This we may call the 'Palæolithic' period. II. The later or polished stone age, a period characterised by beautiful weapons and implements, made of flint and other kinds of stone, in which, however, we find no trace of the knowledge of any metal excepting gold, which seems to have been sometimes used for ornaments. This we may call the 'Neolithic' period. III. The bronze age, in which bronze was used for arms and cutting instruments of all kinds. IV. The iron age, in which that metal had superseded bronze for arms, axes, knives, &c., bronze still being in common use for ornaments, and frequently, also, for the handles of swords and other arms, though never for the blades. Stone weapons of many kinds, however, were still in use during the age of bronze, and even during that of iron, so that the mere

presence of a few stone implements is not in itself sufficient evidence that any given find belongs to the stone age." For instance, I believe that arrow heads of flint, of which there are such large numbers in the Benn collection, continued to be made and used far down into the bronze and iron periods, and it has been asserted that the dark-coloured stone celts or axes, of which such numbers have been found, were in use in Ireland as late as the time of the Stuart monarchs.

The discovery of copper was, of course, what led to the introduction of the mixed metal, bronze, which, as you are aware, is a very hard metal, formed of a mixture in certain proportions of two soft metals, copper and tin. Tin is too soft for weapons of any kind. Copper is not so soft; and, as might be expected, the early metal-workers evidently tried how it would suit for weapons, and accordingly we find axes of pure copper in many collections, but they are very rare. I have not heard of copper spear heads or arrow heads as being found in Ireland. With regard to copper implements in the Museum of the Royal Irish Academy, Sir William Wilde writes:—"The only copper implements of very great antiquity in the Academy's collection are some celts evidently of the very earliest pattern, and greatest simplicity in construction, a couple of battle-axes, a sword blade of the curved broad shape usually denominated scythes, a trumpet, a few fibulæ, and some rudely formed tools. There can be little doubt that these copper celts are the very oldest metal articles in the collection, and were probably the immediate successors of a similar class of implements of stone." In the Benn collection there is one copper celt, rudely fashioned, of flat shape. The scarcity of copper implements in such finds as have been made is probably to be accounted for by the facts that copper was not found to be a very suitable materlal for weapons, owing to its softness, and that bronze superseded it before long; and also because what copper celts were still in the possession of the early metal-workers at the time of the introduction of bronze were re-melted and worked up into bronze implements.

Of bronze celts there are in the Benn collection 85, from

two inches to seven and a-half inches in length. This is a very large number to find in a private collection, and is a proof of the late Mr. Benn's industry in collecting, and also of the exceptionally good opportunities which he had for forming a collection. Of these celts, 54 are either flat-shaped or of the winged form which have been called Paalstab or Paalstav celts. These and the solid celts were, it is supposed, mounted for use by being inserted in a handle of wood, which either lapped over the tang portion of the axe or was pierced by a hole of suitable shape to receive the small end of it. The socketed celts, of which there are 31, were cast with a hollow or socket, into which the wooden handle was inserted; these frequently had small loops cast on at the sides, which were most likely for the purpose of passing a tying through, to secure the head more firmly to the handle. These two classes of weapons—the one in which the metal head was inserted into the wood, and that in which the wood shaft was inserted into the head—are considered by O'Curry to have belonged to two distinct but contemporaneous races of people in this country; and in his lectures he cites an ancient account of the first battle of Magh Tuireadh, which was fought, according to O'Flagherty, in the year B.C. 1272, or, according to the chronology of the Four Masters, in B.C. 1890. The battle was fought between the Firbolgs and the Tuatha Dé Danann, near the village of Cong, in the modern County of Mayo; and the ancient records give very full details of the weapons which were used on both sides. The weapons seem to have been of bronze, and Professor O'Curry examines and criticizes in his usual painstaking way the various kinds of weapons which are mentioned, as regards their form, material, and mode of use; and in translating the Irish names for them he endeavours to identify them with ancient bronze weapons preserved in the Museum of the Royal Irish Academy. O'Curry's arguments are too long for repetition here; but I will read you one extract concerning this battle, which is very instructive in itself, and illustrates the careful way in which O'Curry treats his subject:—"The Firbolgs had settled their seat of sovereignty at Tara, where

they lived under the government of a distinguished warrior, King Eochaidh Mac Erc, when they heard of the appearance of their rivals, who had entered the island on the north-west, and had established themselves in the strongholds of the present County of Leitrim. The Firbolgs, on consultation, determined to send a picked champion of their force to enter into communication with the strangers, and to ascertain what their intentions were; and their choice fell upon Sreng, the son of Sengann; and it is in the description of the meeting of this warrior with Breas, the equally renowned messenger of the Tuatha Dé Danann, that the first description of the weapons on both sides, both offensive and defensive, is found. Without occupying any unnecessary space, then, in detailing the description of the battle itself, I shall proceed to refer to those passages only which contain any description of the shape, size, construction, and use of the various arms employed; and I shall afterwards endeavour to classify these, as well as I can, with reference to the collection of specimens open for examination in the Museum of the Royal Irish Academy. Upon the selection of Sreng by the council of the Firbolgs, 'he arose then,' says the ancient writer, 'and took his hooked, firm, brown-red shield, and his two thick-handled spears called craisechs, and his keen-gliding sword, and his elegant quadrangular helmet, and his thick iron club, and he set out from Tara,' &c. And when Sreng arrived in sight of the camp of the Tuatha Dé Danann, Breas, the champion of the latter, came out to meet and speak with him, 'with his shield upon him,' proceeds the history, 'and his sword in his hand, and having two huge spears with him.' The two champions, we are told, wondered each at the peculiar arms of the other, their form and character being different; and when they came within speaking distance, each of them, it is said, 'stuck his shield firmly into the ground,' to cover his body, while he looked over the top of it to examine his opponent. On conversation, they agree to raise and put away their shields; and Sreng observes that he had raised his in dread of the 'thin, sharp spear' of his adversary; while Breas expresses similar respect for the 'thick-

handled spears' of the Firbolgs, and asks if all their arms are like them. Then, to give Breas an opportunity of examining them, Sreng 'took the tyings off his two thick-handled craisechs' (or heavy spears), and asks Breas what he thinks of them, who replies in surprise and admiration of the 'great, pointless, heavy, thick, sharp-edged arms,' and refers to the sharpness of their touch, their power when cast at an enemy, the wounds that would come of rubbing to their edge, and the deadliness of their thrust; thus describing both the form and modes of use of this peculiar kind of spear. Sreng then explains that the name of the weapon is craisech, that they are 'gorers of flesh,' and 'crushers of bones,' and 'breakers of shields,' and that their thrust or stroke is death, or perpetual mutilation. On separating they exchange weapons, we are told, that the hosts on each side might thus form an opinion of the other by an examination of a specimen of the arms. Breas gives Sreng his two sleghs, or spears, and sends word by him that the Tuatha Dé Danann will insist on half of the island; that they would take so much in peace, but if so much were not conceded by the Firbolgs they must try the issue of a battle between them. Sreng then returns to the Firbolg camp, and it is in his account of the champion of the Tuatha Dé Danann that we have a description of their weapons. 'Their shields,' he says, 'are great and firm; their spears are sharp, thin, and hard; their swords are hard and deep edged.' And Sreng recommended his people accordingly to agree to the proposed terms, and to divide the country equally with the strangers. This, however, they would not consent to do, for they said if they gave the Tuatha Dé Danann half they would soon take the whole. On the other hand, the Tuatha Dé Danann were so much impressed with the report of Breas, and with the appearance of the terrible craisechs, that they resolved to secure themselves by taking up a better military position before the impending battle, and they retired accordingly farther west into Connacht."—["*Manners and Customs of the Ancient Irish*," by E. O'Curry; vol. ii, p. 235.] After this follows an account of some of the events of the battle, in which the uses

of the several weapons are most minutely described. O'Curry also gives an account of the second or northern battle of Magh Tuireadh, fought thirty years later than the first, between the victorious Tuatha Dé Danann and the Fomorians, or sea rovers. In this account, the weapons are described still more fully. And in an account of a later battle, that of Ath Comair, O'Curry again goes most minutely into the subject of the weapons used, and he draws particular attention to a missive weapon called a "lia lamha laich"—translated a "champion's hand-stone"—which was carried for use in the hollow of the shield, and which O'Curry suggests was the polished stone "celt," of which I have lately been speaking.

Of bronze sword blades, and what may be called dagger blades, there are in the Benn collection 24. Of bronze spear or lance heads, many being of beautiful workmanship, there are 26; these have sockets for the insertion of the shaft. The sword blades, on the contrary, were made with rivet holes, and were rivetted to handles which were made of scales of wood, bone, or hard tusks, such as those of the sea-horse. There are about 30 bronze brooches and pins. It is in antiques of this class that we find some of the most exquisite workmanship of the old artificers. Some of Mr. Benn's are richly ornamented, and are worthy of a careful examination.

There are many other bronze objects, to some of which it is difficult to assign either a name or use. Some of them are, undoubtedly, parts of horse trappings, spurs, bits, &c., many rings of bronze, which have evidently been cast, and some of which are still adhering together in twos and threes, as they came from the mould. There are some small finger rings and seals of different materials; and a curious object made of thin bronze, hollow, and evidently in imitation of a human finger, with the nail and folds of skin at the knuckles all complete. This probably was the case or shrine in which the finger bone of some saint was preserved as a relic. There are two bronze smoking pipes and two iron ones, and also a brass or bronze "beggar's badge," issued in the parish of Shankill in 1774. The most interesting object of bronze, and perhaps the most

interesting object in the whole collection, is the small urn, or vase, bearing an Irish inscription, which has lately been described in Miss Stokes's work on "Christian Inscriptions in the Irish Language." This little urn, which probably was an altar vessel, was described by the late Dr. Petrie, in the *Dublin Penny Journal*, vol. ii. He says: "This very interesting little altar vessel . . . . was found in the ruins of an old church in Islandmagee, in the County of Antrim, and fell into the possession of an old woman in the neighbourhood, who used it for many years to hold oil for her spinning-wheel. Its workmanship is of great beauty, being not only of graceful proportions, but as round and smooth as if turned in a lathe. The inscription round its neck, which is in a beautiful square Irish character, enables us to ascertain with precision its age and original owner. It is as follows: 'Pray for Martin O'Brolachain.' From the 'Annals of the Four Masters,' as well as from the 'Annals of Innisfallen,' we find that this Martin O'Brolachain was professor of divinity in the Abbey of Armagh, and died in the year 1188. He is designated as the most wise of all the Irish of his time." Mr. Benn was owner of this precious relic in 1832, having rescued it several years previously from its ignoble position at the old woman's spinning-wheel. Miss Stokes, in her work, gives a different reading of the inscription, and no doubt the correct one. It reads: "OR DO M[AC.]ETAIN AU BROLCHAIN" (pray for Mac Etan, descendant of Brolchan ;) and it would seem that this individual has not been identified, although several members of this family belonged to Armagh, and others were connected with the church at Kells. The vase is two-and-three-quarter inches in height, and seven inches in circumference.

In the collection there is an ancient square ecclesiastical bell, found near Ballymena; a small square bell, cast of bronze; and some of the round bells or crotals, which, however, are not ancient. There is also a large rivetted caldron of a well-known type, and a circular brazen dish, which was found at a crannog near Randalstown. At this crannog, or lake dwelling, many objects of human manufacture have been found from time to

time. In the collection there are a few articles of wood—namely, two paddles from the peat which occupies the site of a dried-up lake, a wood spade, a cattle yoke, and some methers, or drinking cups. There are three gold ornaments and a silver bracelet.

I think most of the antiquities in the collection have now been noticed, with the exception of the coins, of which there is a very large series. To deal effectively with these requires a special knowledge, and I will now express a hope that the coins in this collection may shortly be catalogued, and that a notice of them—especially of the rarities among them—may be brought before the Society. I may say that there is an entire series of the tokens of the Belfast merchants of the seventeenth century, with one exception, that of the joint token of Thomas Atkins and William Lockhart, of which there is a beautiful drawing by Dr. Aquilla Smith, of Dublin. These tokens are about 30 in number. A very interesting token in the collection is that of W. Johnston, of Belfast, of which only this one specimen is known to exist. From its size and the character of the letters, it may probably have been issued early in the eighteenth century. It probably represents on copper a part of High Street as it then was; the market-house, with its little steeple; the river, apparently unenclosed, flowing in an open stream, and one of the bridges which crossed it. It is strange that no other specimens of this "Belfast ticket" have turned up.

Mr. Benn has also presented, with the collection, a number of valuable books on antiquarian subjects. I estimate that, not counting the coins, there are in the Benn collection about 1,500 separate objects. These, along with the collection of Irish antiquities already in the Society's Museum, will form a very fine nucleus, around which, it is to be hoped, many interesting objects will from time to time be gathered. The Irish antiquity room should form, and I expect will form, one of the chief attractions in our Museum.

30th November, 1880.

Mr. Robert L. Patterson, Vice President, in the Chair.

A Paper was read by Thos. Workman, Esq., on

THE HISTORY OF ISLANDS, AS TOLD BY THE ANIMALS FOUND ON THEM.

Having in a few words shown that, previous to the publication of Mr. Darwin's work on the "Origin of Species," the ideas held as to what constituted a species were very different from what naturalists now hold, the lecturer went on to describe the situation and peculiar fauna of the Azores, Madeiran, Canary, and Cape Verd Islands. He showed that there were very conclusive grounds for believing that the animals found on these islands were of Palæartic (or Europeo-Asiatic) origin ;—though many of them are specifically different from their allies in Europe, yet that difference has been brought about by their peculiar position and long-continued isolation. To show that there has been no land connection between these islands and the mainland from the most remote period, Mr. Workman pointed out that there are no terrestrial mammals, toads, or frogs found on them ; and, though there are enormous numbers of different species of apterous (or wingless) beetles found in South Europe and North Africa, yet these islands possess only a few species, and these exceptions go to prove the rule. For instance, the genus Meloe has three species found in these islands, but as in its larval form it is parasitic on bees, its presence is easily accounted for. Also, many species that are winged in Europe are wing-

less in these islands, and this remarkable fact is accounted for in this way, that wings are not absolutely necessary for these species, and, therefore, those insects which are frequent flyers are blown out to sea, while the more sluggish individuals who either cannot or will not fly remain to continue the race. This process, continuing from generation to generation, would, on the well-ascertained principle of selection and abortion by disease, in time lead to the entire loss of wings by those insects to whom wings are not a necessity. Those insects to which wings are a necessity to obtain their food or to provide for their offspring are found, in many cases, to have more powerful wings than individuals of the same species in Europe.

The lecturer then described the remarkable fauna of the little island of St. Helena, and tried to show that its origin is also Palæartic, although the island of St. Helena is situated 1,000 miles to the south of the Equator, and more than 1,800 miles south of the Cape Verd Islands. He pointed out the intimate connection between the insects found on St. Helena and the Cape Verd and Canary Islands, and suggested that there was a likelihood that in geological times there were many islands in the Atlantic Ocean, bridging over this enormous distance, whose former existence is now marked by rocks and shoals, and that by means of these stepping-stones the aboriginal inhabitants of St. Helena arrived. Also, that there is reason to believe that during one of the glacial periods the ocean currents in the South Atlantic were reversed, and that the same cause would drive animals to seek more southern climes. The insects and shells on the island of St. Helena are very different from those found elsewhere. There are no mammals, reptiles, or fresh-water fish, and only one species of land bird found on it, showing that St. Helena has been disconnected from other islands from an extremely remote time.

21st December, 1880.

Thomas Workman, Esq., in the Chair.

A Paper was read by Joseph John Mubphy, Esq., F.G.S., on

THE PROBLEM OF GEOLOGICAL CLIMATES.

It has long been known that fossil remains of plants and animals are found in the temperate and colder regions of the earth, of similar species to those which are now found living in much warmer climates, thus proving that, in remote geological periods, what are now the temperate and cold latitudes were much warmer than they are at present; and evidence, mostly of a different kind, consisting of ice-borne boulders and glacial scratches on rock, has now made it equally certain that, in comparatively recent geological periods, icebergs and glaciers had a much greater than their present range.

Various causes have been suggested for these changes of climate. It was formerly a favourite idea, that in the early geological periods the cold crust of the earth was thinner than at present, and that the air was warmed by the earth's internal heat. This, however, is now, I believe, universally abandoned. Sir William Thomson and all the best authorities are agreed that, so soon as the earth's surface was sufficiently cool and consolidated to admit of vegetable and animal life on the land, the escape of internal heat would be too small to have any perceptible effect on the temperature of the air.

It has been suggested that the solar system may be moving, in the course of successive ages, through hotter and colder

regions of space. It appears certain, however, that we receive scarcely any heat from the stars; so that we can never have passed through a colder region than that which we are passing through at present; and it does not seem at all probable that our system, since its first formation, has ever been near enough to any of the stars to be sensibly warmed by them.

Three causes remain which have probably, indeed almost certainly, had their influence in changing the climates of our planet. These are—

1. Changes in the relation of the earth to the sun in its orbit.
2. The secular cooling of the sun.
3. Changes in the distribution of land and ocean.

I maintain that glacial climates have been due to changes in the relation of the earth to the sun;—that the warm climates of the early geological periods were due to the sun's heat being greater than at present;—and that the effect on climate of changes in the distribution of land and ocean, though probably of sensible magnitude, has not been very great.

Respecting the first of these three causes, I have little to add to what was contained in my paper on "The Glacial Climate and the Polar Ice-cap," which was read to this Society on the 1st December 1875, and afterwards printed in our Proceedings. I will briefly recapitulate what I then offered as an explanation of the glacial climates.

The chief cause of glaciation is neither a low mean temperature nor a cold winter, but a cool summer, which leaves the snow of winter unmelted. This is shown by the fact that the height of the snow-line on mountains is chiefly determined by the summer temperature;—the warmer the summer, the greater is the height to which we must ascend in order to find perpetual snow;—winter temperature has no effect on it.

Supposing the sun's heat to be constant, the total heat received by the earth from tbe sun in the course of a year is very nearly constant from year to year; but the excentricity of the earth's orbit is subject to considerable though very slow

changes, which greatly affect the distribution of heat over the seasons of the year. We are at present, and have been for 80,000 or 100,000 years past, in a period of small excentricity. At present the earth's aphelion, or maximum distance from the sun, occurs near the midsummer of the northern hemisphere. When the position of the aphelion in the year was the same as at present, while the excentricity was at the greatest, our planet received at midsummer of the northern hemisphere nearly a tenth less heat than it does at present, so that the snow of winter would not be melted in summer to anything like the extent that it is now, and many parts of the lands of high northern latitudes, which are now covered with vegetation, were then buried under continental ice like Greenland. At the same time, the great heat of the summer in the non-glaciated hemisphere, where the perihelion would fall at midsummer, would raise a great quantity of vapour, a part of which would be condensed and fall as snow in the glaciated hemisphere, thus increasing its glaciation; and this action would be promoted by the active circulation of the winds between the summer and the winter hemispheres, which obviously must be greatest at the perihelion of maximum excentricity.

After about 10,500 years, the aphelion would have moved round to the midsummer of the opposite hemisphere, which then became the glaciated one; so that, while a period of great excentricity lasts, the two hemispheres are glaciated alternately. The periods of great excentricity are of irregular duration, but very much longer than 10,500 years;—we ought consequently to expect to find geological evidence that the glacial climate has not been continuous but intermittent and recurrent, with warm, or at least not glacial, periods between; and there appears to be satisfactory evidence of this.*

Mr. Croll has the great merit of being the first to call attention to the effect on climate of changes in the excentricity of the earth's orbit, and has stated his views at length in his work on *Climate and Time*. He has, however, made what I think the mistake of attributing glaciation to winter cold, and con-

* See Croll's *Climate and Time*, ch. 15, "Warm Interglacial Periods."

sequently placing the glacial period of either hemisphere in that portion of the cycle where the aphelion occurs in the winter.

There is one conspicuous fact of the present physical geography of the earth which appears to support Mr. Croll's opinion. The earth's aphelion occurs at present in the winter of the southern hemisphere, and that hemisphere is the most glaciated of the two;—the entire Antarctic Continent is covered with an ice-cap down to the water's edge; while in Greenland, on the contrary, the covering of continental ice in most places does not come down to the sea, and in Siberia and North America there is no continental ice at all. This however is amply accounted for by the great extent of ocean in the southern hemisphere. Water has the greatest capacity for heat of all known substances, and consequently takes a long time to heat and a long time to cool. For this reason masses of water tend to equalize the seasons, mitigating both summer heat and winter cold; and the depression of summer temperature in the southern hemisphere, due to this cause, lowers the snow-line and promotes glaciation.

But if land and water were equally distributed over both hemispheres, I cannot doubt that the fact of the perihelion occurring in the summer of the southern hemisphere would raise the summer temperature of that hemisphere, and cause it to be less glaciated than the northern. This is the state of things at present in the planet Mars. The proportion of land to ocean is greater in Mars than in the earth, and they are nearly equally distributed over the two hemispheres. In Mars, as in the earth, the perihelion at present coincides with midwinter of the northern and midsummer of the southern hemisphere; and the excentricity of his orbit is somewhat greater than that of the earth at its maximum. We ought consequently to expect the extent of permanent snow to be much less round the south than the north pole of Mars, and this is what has been observed. Round each pole there is a permanent snow-cap. The northern one was observed in 1837, and its least diameter, which was shortly after the midsummer of that

hemisphere, was 15° 20′; so that it had a radius of half of this, or 7° 40′, from the pole as centre. The southern cap was observed in 1830, and its least diameter was 5° 46′, (or a radius of 2° 53′;*) and Schiaparelli states that it has once been seen to disappear. The snow-caps grow visibly smaller, almost from day to day, under the summer sun. This shows that the depth of the snow cannot be very great. Their diminution, as Mr. Wallace remarks, is exactly similar to the rapid melting of the snow on the plains of Siberia and North America. If astronomers in Mars were to watch the earth, they would see the snow disappearing every summer from extensive tracts of land round the North Pole, while the ice-cap which surrounds the South Pole and covers the Antarctic Continent would be always seen of the same size. This would be very perplexing, and would perhaps give rise to doubts whether the white surfaces that they saw around the earth's poles were of snow at all, until it was seen that the southern snow-cap was surrounded by a bluish expanse which was probably a vast ocean, and it would be obvious that great fields of snow cannot be formed and disappear again over water as they can over land.

When it became known that glaciers and icebergs once extended over great regions now free from them, it was an obvious guess to make, that the sun must at that time have been colder than at present. This however seems impossible; for no agency appears to exist in nature, or to have ever existed since the first condensation of the sun out of the primary nebula, whereby his stock of heat can have been greatly increased. The idea at one time gained currency, that the sun is constantly receiving supplies of heat by the falling in of meteors from external space on to his surface;—I think there is good reason to believe that this is the source of a sensible though small part of the heat which he is always radiating away;—but if we suppose that the sun was much colder 100,000 years ago than now, we must suppose that the supply of in-falling meteors has increased during that time so as to supply a large part of his present heat; and the existence of so great a quantity of

* Edward Carpenter, in the *Geological Magazine*, March, 1877.

meteoric matter, circulating near the sun, as this hypothesis would require, appears to be inconsistent with what we know of the equilibrium of the solar system.

Moreover, it does not appear at all probable that a colder sun would produce a glacial climate. The chief requisite for the production of glaciers, and consequently of icebergs, which are floating fragments of the vast Polar glaciers, is the fall of snow; the snow-bearing clouds are fed by evaporation, and evaporation requires solar heat; so that, as Tyndall has expressed it, diminution of the sun's heat would cut off the glaciers at the source. We may no doubt imagine such cold as would freeze the oceans to a distance of forty-five degrees of latitude round each pole, but this would not account for rocks scratched by glaciers and boulders borne by icebergs, for these show the icebergs and glaciers to have been in motion.

On the other hand, the fact of the climate of, at least, the higher and middle latitudes having been formerly much warmer than at present, may be reasonably accounted for by supposing that the sun was then hotter than now; and this is not only an admissible supposition, but appears to be necessarily true; because a body which is constantly emitting heat must in the course of time grow cooler, unless it receives supplies of heat or of fuel from without; and in the case of the sun this appears impossible, except to a comparatively small extent, through the in-falling of meteors. Heat is probably being produced by the subsidence, or falling in, of his surface, but no action of this kind can sustain the temperature at the same level for an indefinite time.

If "the imperfection of the geological record" * permits it, we ought to expect to find evidence of a progressive cooling; and the fossil flora of the Arctic regions does seem to yield such evidence. On this subject we have abundant information from the discoveries of Professor Nordenskiold, who has probably done more than all other explorers put together to increase our knowledge of Arctic geology, and from the researches of Professor Heer of Zurich on the fossils brought home

* This is Darwin's expression, being the title of a chapter of his *Origin of Species.*

by Nordenskiold.* In extreme outline, the facts are as follows:—

The oldest vegetable forms found fossil in the Arctic regions are Sigillaria, Calamites, Lepidodendra, and other plants characteristic of the Coal period, and showing a warm climate; and the corals and shells bear the same witness. In the Jurassic strata Cycads and Conifers are found, the representative species of which now grow in the neighbourhood of the tropics. During the Cretaceous period, a great change occurred. In the lower Cretaceous periods, the characteristic forms are Ferns, Cycads, and Conifers; but before the conclusion of the period these had given place to deciduous trees and other Dicotyledons, among which are a Ficus and two species of Magnolia. In the Miocene beds, besides plants belonging to a warm climate, we find trees characteristic of a temperate climate like that of Central Europe at present, such as limes, oaks, beeches, planes, and large-leaved birches.

These facts appear to show a progressive fall of temperature, indicated first by the transition from Ferns and Cycads to deciduous trees, and afterwards by the disappearance of these latter, giving place to the present Arctic flora. The fall of temperature, as Heer remarks, was probably accompanied by a clearing away of cloud at the transition from Ferns to Dicotyledons.

I cannot however agree with Heer and Nordenskiold that there ever was a time, since life began, when all latitudes had the same climate; but it is probably true that when the solar heat was the greatest the difference of climate between different latitudes would be the least, because the amount of evaporation increases very rapidly with increasing temperature, and the higher latitudes would be warmed by the heat liberated in the condensation of vapour which had been evaporated in the lower latitudes. Moreover, the heat of the equatorial regions would be mitigated by a veil of cloud screening the earth. But if all latitudes had the same temperature, there would be no cause to produce atmospheric currents between different latitudes, and

* See the *Geological Magazine*, November, 1875.

thereby to cause vapour which had been evaporated near the equator to be condensed about the poles.

We have still to consider the possible effect on climate of changes in the distribution of land and ocean. Sir Charles Lyell appeared to think that a warm climate over the whole earth might be due to a preponderance of land near the equator and of sea about the poles; and that the reverse arrangement would account for a glacial climate. It is quite true that a polar continent, surrounded by a vast ocean, would be eminently favorable to glaciation. We see this in the Antarctic regions now. But it does not appear to be true that the substitution of land for sea about the equator would have any tendency to raise the polar temperatures, but rather the reverse, because in that case there would be less evaporation about the equator, and consequently less condensation about the poles, and less liberation of latent heat.

Mr. Wallace, in his *Island Life*, has lately maintained that the high polar temperatures of the pre-glacial periods may be explained by supposing that there was formerly a more open and free communication than at present between the tropical and the polar seas;—that, as he puts it, there were several Gulf Streams instead of one passing comparatively warm water into the polar seas. This might be satisfactory if we had to do with mean temperatures or winter temperatures; but I have endeavoured to show that glaciation is almost exclusively determined by the summer temperature, and we know that the distribution of living beings is mainly determined by the same;—whereas an examination of Dove's map, showing the isothermal lines for January and July, will make it evident that the effect of the Gulf Stream on climate, though very considerable, is chiefly confined to the winter. The late Mr. Hopkins, of Cambridge, in his well-known paper on geological climates,* estimated the effect of the Gulf Stream on the July climate of London as null.

It would however probably make a sensible improvement in the summer climate of the Polar basin if the slope of the Asiatic

* *Journal of the Geological Society*, 1851.

and North American continents were so changed that no great rivers were to flow into the Arctic Ocean, because the ice from the Siberian and North American rivers greatly lowers the summer temperature there.

It is worth remarking, that throughout all geological time the northern hemisphere must have been comparatively continental with a continental climate, and the southern hemisphere oceanic with an oceanic climate. The arrangement of land and water on the earth's surface is such, that a hemisphere of which England is the centre contains a greater proportion of land than any other hemisphere that can be drawn, and the opposite hemisphere a greater proportion of water. This is obviously due to a slight excentricity of the earth's centre of gravity as compared with her centre of figure, drawing the water of the ocean to the farther side from us; and no geological revolution can have materially altered this, which must have been fixed at the original condensation of the earth.

To return to the subject of the former greater heat of the sun;—we have seen that a much colder sun would not produce glaciation; but on the other hand it is evident that a very hot sun would prevent glaciation, by melting the snow either before it fell or soon after. Nordenskiold states that there is a total absence of any evidence of glaciation having occurred in the Arctic regions during the Tertiary period, although such evidence, consisting chiefly of ice-borne boulders, could not be destroyed except by such denudation as would have removed the strata altogether. It appears safe to attribute this to the greater heat of the sun during the Tertiary period, which is also attested, as we have seen, by the fossil vegetation.

There is however some evidence of glaciation in Eocene and Miocene times, not regularly recurrent, but only occasional as to place and time. Those cases which appear to be most clearly made out are in Switzerland and Piedmont, near the Alps;* and there is no difficulty in seeing how vast glaciers might proceed from the Alps at a time when none were formed on

* Croll's *Climate and Time*, pp. 305, 306.

the much lower mountains of the Arctic regions. Vast glaciers would be formed so soon as the sun had cooled down sufficiently to permit of perpetual snow remaining at all, because the greater heat of the sun would produce greater evaporation than at present, and consequently greater snowfall.

18th January, 1881.

The President, Professor Purser, in the Chair.

A Paper was read by Thomas H. Corry, Esq., M.A., M.R.I.A., F.Z.S., on

THE MOVEMENTS OF FLUIDS IN PLANTS.

The subject which will engage our attention this evening is perhaps the most important in the whole science of Vegetable Physiology, and though it has received attention from investigators for nearly two centuries, it appears even yet, so far as the present state of our knowledge extends, impossible to give an adequate, definite, and deductive account of the *modus operandi* of these movements in detail. Certain of the facts, however, are well known and established by experiment, while over others hangs a shadow of uncertainty, since we are compelled to draw our conclusions as to the internal processes, on all essential points, from a careful study of the external phenomena in the plants themselves; for the forces acting in the living plant act under conditions which are widely different from those which obtain in the ordinary apparatus of the laboratory.

I will begin by describing the structure of one of the simplest plants, viz., Pandorina. It consists only of a single mass of living tissue, which we call *protoplasm*, surrounded by a clear, glassy, transparent envelope or wall, termed the *cell-wall*, for we designate the lump of living protoplasmic material as a *cell*, and speak of this plant as being unicellular. This envelope is not of universal occurrence in plants, for certain plants, during either the whole or a portion of their existence,

possess no cell-wall ;—it is derived from the protoplasm by a process of change. Of its more minute structure and properties I shall presently have to speak.

The protoplasm, or living and essential constituent of the structural element or cell, is at first clear, and transparent; often, however, we find that it is more or less opaque, exhibiting a turbid whitish granular appearance; the granules which render it so being due to the presence of drops of oil, granules of starch, or granules of inorganic salts. The layer of protoplasm, which lines every portion of the cell-wall, is not uniformly granular throughout, for between the granular portion and the cell-wall there is a clear space, and the protoplasm here is transparent, hyaline, and harder than the inner portion. Consequently there is a division of the protoplasm into two distinct portions—a granular portion or *endoplasm*, and a hyaline portion or *ectoplasm*. The ectoplasm is comparatively inactive in the performance of the chemical processes which go on in the cell; it is protective of the inner active region, and hence probably its clearness is due to the fact that no foreign bodies are needed there. This differentiation of the protoplasm into two also occurs in organisms which are destitute of a cell-wall. In the centre of the mass of protoplasm is a body with a well-defined outline of a darker colour than the protoplasm, and in some cases appearing to be merely slung in certain bridles of it, (as in the cells of the filaments of Tradescantia); this body is nothing but condensed protoplasm, and is called the *nucleus*. Nuclei have of late been detected by a German observer in the cells of the Fungi, and of the lower Algae, where they were for a long time supposed to be absent, and here they are not single, but in great numbers, so that if these observations be trustworthy, we do not know of any vegetable cell which does not at some period possess a nucleus. The function of the nucleus is to act as a governor or director of the protoplasm of the cell, and hence it presides over division, and is usually the first portion of the cell to divide. As the cell increases in age, minute clear spaces called *vacuolae* make their appearance in the protoplasm; these are filled with a watery fluid known as

the *cell-sap*; these vacuolae extend, and uniting in the centre of the cell, give rise to a large clear space filled with fluid, which is called the *cell-vacuole*; as the cell increases in age, the endoplasm becomes changed and used up in the process of nutrition, so that in the cell in age we find nothing but the cell envelope, perhaps a lining of ectoplasm, and a central space filled with cell-sap.

It is by means of this cell-sap that the plant can take up from outside the fluid substances required for the nutrition of the protoplasm. It usually contains dissolved in it a number of substances either used for the growth of the cell, or excretions of the activity of the cell, *e.g.*, sugar, vegetable acids, colouring matters, seen in the cell-sap of Virginian Creeper (Ampelopsis hederacea), which produces the red appearance of its leaves in autumn and winter; and also in the purple colour of the filaments of the stamens of Tradescantia. Its contents depend on the age and activity of the cell. The cell-sap acts then as a storehouse whence the protoplasm may build itself up, and also a reservoir for the products of its disintegration.

In order that we may obtain a right appreciation of the phenomena presently to be described, it is necessary that some notice of the minute structure, and mode of growth of the cell-wall and of the protoplasm, should precede our account of them.

Our knowledge of this portion of the subject is due to the patient and accurate investigations of Carl Von Nägeli,* who obtained the first generalizations, through an elaborate and painstaking study of the structure and physical properties of starch grains. Afterwards it was applied to the cell-wall in general, and then to the protoplasm. The facts to be briefly noticed constitute what is known in Vegetable Physiology as "Nägeli's theory of the structure of the cell-wall, and of other organized bodies."

Cell-walls, starch grains, and protoplasmic structures, consist in their natural condition, at every point that can be seen even

* Nägeli, Pflanzen Physiologische Untersuchungen, Vol. 1, Parts 1 and 2. Nägeli and Schwendener, Das Microscop, Vol. II., p. 402, *et seq.*

under the microscope, of a combination of solid material with water; but when the cell-wall is very thin, no microscopic observations can show that the cell-wall has any particular structure, and it appears to be a perfectly homogeneous membrane. If these organized structures are placed in, or treated with, a reagent such as alcohol, which is capable of removing water, a part of their aqueous contents is withdrawn, and consequently they diminish in size; while on the other hand, when treated with certain reagents, such as dilute acids and alkalies, they have the peculiar property of swelling up—that is, of absorbing a certain amount of fluid, with a consequent increase of bulk. From these phenomena Nägeli inferred that the starch grain, for example, consists of isolated solid particles, which are themselves impenetrable by water, but which are capable of taking up a certain amount of water between them, and that the amount of this water may vary according to circumstances. The swelling up, then, depends on the taking up of a certain quantity of water, and the temporary retention of the same between the particles of the cell-wall; and upon this property of swelling up the growth in size, and the peculiar shape of the cell depend. Within certain limits, these variations in the proportion of water to solid matter may occur without occasioning any permanent change in the molecular structure; but if, with a higher temperature, and in presence of chemical reagents, the proportion falls below a certain minimum or exceeds a certain maximum, permanent changes in the internal structure take place, which can no longer be reversed, and the internal organization of the body becomes partially or entirely destroyed.

Every molecule of a saturated organized body is, on this theory, surrounded by layers of water, by which the adjacent molecules are completely separated from one another. These molecules are solid and relatively unchangeable, and invisible even with the highest attainable microscopic powers. We may compare the whole cell-wall to a brick wall or to a regiment of soldiers seen at a distance, which, on closer inspection, we find to be composed of smaller particles, viz., bricks or men. When

the starch granule is absolutely dry, these solid particles—to which Nägeli gave at first the name of *molecules*—apparently come into perfect contact, for the granule does not lose its transparency, which would be the case if air were included in its substance. Hence the first inference we may draw from this, as to the form of the molecules, is that the particles are not spherical or oval, for in that case the starch grains would of necessity contain air when dry. They must be, therefore, more or less polyhedral, but they are not equi-axial, since the swelling up does not take place equally in all directions. The word *molecule* used at first by Nägeli to designate these solid particles has not the same sense as when it is used in Chemistry, for one of these molecules of Nägeli is probably an aggregation of a larger or smaller number of chemical molecules; and, therefore, in order to avoid any confusion on this score, the word *micella* has been substituted by him in his more recent works. These micellæ may be supposed to be of various sizes, and it is evident that, if the thickness of the aqueous envelope be the same, larger micellæ will form a more dense, and smaller micellæ a less dense structure. It is well known that organized structures, such as the cell-wall and starch grains, exhibit an appearance of *stratification* when examined under the microscope—that is to say, of an alternation, in one or more planes, of more and less dense layers;—these were formerly supposed to indicate the successive layers of deposition of cellulose in the one case and of starch in the other—internally in the case of the cell-wall, externally in the case of the starch grain; while in reality the appearance is due to an alternation of layers containing larger and smaller micellæ. In all cases the proportion of solid to fluid is greater in the dense than in the less dense layers; or, in other words, the relative size of the micellæ to the watery areas which surround them is greater in the layers of greater density.

The changes in volume of organized bodies due to the removal of water or its absorption, depend, then, on the fact that when swelling up takes place the micellæ are forced farther apart by the water which penetrates between them, while, on

the other hand, they approach one another in proportion as water is withdrawn from between them. But it may be asked, How can such a structure as the cell-wall hold together? The forces by which these micellæ, with their surrounding watery areas, are held together, are :

1st. The attraction existing between the separate particles of each micella holding them together and rendering them impermeable to water ;—since we saw that each micella was itself probably an aggregate of chemical molecules.

2nd. The attraction of the micellæ for one another, in consequence of which they tend mutually to approach.

3rd. The attraction which exists between each micella and the water which surrounds it. This acts, of course, as a counteracting influence to the second.

It is obvious that the attraction existing between the micellæ and their surrounding watery areas must necessarily be greater than that of the micellæ for each other, otherwise the micellæ would attract one another and exclude the water ; but whereas the latter attractive force varies inversely as the square of the distance, the former must vary inversely as some higher power.

Thus, if A represents the attraction between two micellæ, B represents the attraction between a micella and the water, while D is the distance between two micellæ, the limit of swelling up or imbibition will be reached when $\frac{B}{D^{2+x}}=\frac{A}{D^2}$ between any two neighbouring particles. B, however, will diminish more rapidly as the distance increases.

This theory of Nägeli affords a satisfactory explanation of the mode of growth of a cell-wall. It is easy to understand that when the limit of extensibility is nearly reached—that is, when the micellæ of the membrane are separated as far as it is possible for them to be—new micellæ can be deposited in the interstices, and the extended condition can be thus rendered permanent, and made a basis for further extension. This mode of growth is commonly known as *growth by intussusception*, or by

intercalation of new particles. But this is not all that has been determined with regard to these micellæ, for in 1862 a paper appeared by Nägeli,* in which were contained these results. He found, in the first place, that organized structures, such as starch grains and cell-walls, are doubly refractive under the polariscope; and further, that this property is not affected by causing them either to increase or to diminish in size either in consequence of absorption or removal of water, or by mechanical stretching or pressure. It is well known that double refraction is a property characteristic of some crystals, and hence it might be supposed at first by some, that the cell-wall was simply a crystallization outside the protoplasm; but if this were so we could interfere with its optical properties just as we can do with the optical properties of crystals, for these last, when treated with reagents, swell up, and their double refraction either disappears or is changed in a marked degree; but, as we have just stated, Nägeli found the reverse to be the case with regard to the micellæ. He concluded, therefore, that the double refraction is not a property of the organized structure as a whole, but that it belongs to each individual micella; and hence these micellæ must be crystalline. Again, from the interference colors which these objects present when examined with polarized light, he ascertained that the crystalline micellæ have three axes of elasticity, that they must be biaxial crystals; and further, by comparing the effect produced by the passage of polarized light through glass under various degrees of pressure, he arrived at the conclusion that the micellæ are so arranged in the membrane of which they form part, that one of their axes of elasticity is perpendicular to the surface, while the other two axes lie in the plane of the membrane. Nägeli has also shown that the crystals of proteid substance which occur in various seeds and tubers have the same molecular constitution as starch grains and cell-walls. The outcome of this theory in relation to the movement of fluid in the wood will be seen hereafter. At present we will only pause to notice in how far it is applicable to the protoplasm. There can be

* Proceedings of Bavarian Academy, 1862.

little doubt that it is justifiable to extend this theory to the explanation of its intimate structure also. It is true that the protoplasm swells up under certain solutions in the same way as the cell-wall does, and hence we may conclude that it also is built up of minute solid particles, separated by areas of fluid; but as to their form, shape, and size we are at present entirely ignorant except in this one particular that they do *not* act on polarized light in such a manner as to suggest that they are crystalline.

Next we have to consider the *general properties of a cell.* If we cut a thin section of some colored portion of a plant—*e.g.*, a beet-root—and place it under the microscope, we can observe in each cell the cell-wall, protoplasm, nucleus, and cell-vacuole, in which latter we find contained a bright red-colored fluid, which is the cell-sap, in this case colored red. If such a section is left in water for some time, nothing particular will be found to take place; all the parts will retain their position. We have, then, a vesicle containing red coloring matter which is soluble in water placed in water, yet the red fluid does not escape from the cell into the water. If we repeat the experiment by placing some red fluid on an animal membrane, and then floating the latter on water, the red fluid will soon be found to dialyse—*i.e.*, pass through the interstices between the solid particles of which the membrane consists, from the exterior into the water. What prevents, then, the same result in the previous experiment with the beet-root? We would find, if we were to leave the section for days and weeks in water, that no escape of fluid would take place, and an escape of fluid would only occur when the entire disintegration of the cell by bacteria—or, in other words, its death—occurred also. The cells of the beet-root, then, though placed in water, are still living, not dead, and it is only when they become dead that the red fluid contained in them escapes through the cell-walls. If, however, another section be plunged for a few minutes into strong spirit, when it is afterwards immersed in water the red fluid escapes directly through the wall, proving further that this property of retention depends on the life of the cell. The only living part of the cell is the

protoplasm, and this retaining property is due, then, to the protoplasm lining the cell-wall. For if a section of beet-root is placed in a tolerably concentrated solution of some salt, such as nitrate of potash, or common salt, the cell-wall will not be found to alter much in shape, but the layer of protoplasm lining the cell-wall will contract away from it towards the centre, and form an irregular bag in the middle of the cell, leaving a large space between it and the cell-wall—*i.e.*, we have produced a plasmolytic condition of the protoplasm. Yet, though the protoplasm has contracted, the red fluid contained in the vacuole has not escaped; and since it is plain that the fluid in its integrity could not have remained in the cell in its now reduced size, something must therefore have passed out, what has done so being simply pure water. The protoplasm, then, so long as it is living, prevents coloring matter passing out through it, and this is true also of other substances—*e.g.*, grape sugar, which occurs abundantly in the beet-root's cells, dissolved in the red cell-sap. While an objection might possibly be entertained to the evidence of the red coloring matter, inasmuch as it belongs to the class of bodies denominated "*colloids*" by Graham, the case of the sugar presents no such ambiguity, because it is a crystalline substance belonging to Graham's class of "*crystalloids*," and, therefore, should dialyse through a membrane such as the cell-wall, were it not for the retaining power of the protoplasm exercised upon it; for even in the plasmolytic condition above described it is still impossible to detect any trace of cane sugar outside the cell. But it may be objected that in plasmolysis you have destroyed the life of the cell. That this is not the case may be satisfactorily demonstrated; for it is possible, by gradually diluting the salt solution with water, to bring the cell back again from the plasmolytic condition into a turgid state, yet during all this time there has been no escape of the coloring matter. Precisely the same effects will occur if these experiments are repeated on a growing plant, which will go on growing as before after they are over, so that this is proof enough that they do not destroy the plant's life. As we shall see, these observations

are of great importance in connection with the absorption of water by the roots of plants. To sum up, then:

The cell-wall is a membrane which permits of the passage of any dialysable substance through it. This may be easily shown by placing the cell in currant juice or litmus solution, which will not destroy its life, when we obtain the converse of the experiment last detailed. The cell-sap and protoplasm do not either of them become colored, but if the solution of coloring matter used be tolerably concentrated, a plasmolytic condition will be produced, and the intermediate space between the contracted protoplasm and the cell-wall will become filled with the colored fluid, which, though it has passed through the cell-wall, yet does not pass into the vacuole through the protoplasm. The cell-wall is also very elastic, since the cell is capable of taking up into itself a considerable amount of fluid, and within certain limits the cell-wall gives way to the strain so produced, while, if conditions are present by means of which the fluid is withdrawn again from the cell, the cell-wall contracts like an elastic bladder, and returns again to its normal limits. In plasmolysis the cell-wall maintains its form though it diminishes in size; since the internal pressure which caused tension has been removed, it in consequence has contracted, although it still retains the same shape as before. The protoplasm has the the power of resisting the passage through it of certain substances, and hence we cannot apply to it the ordinary principles of dialysis, though we can give expression to these physical principles in a mathematical form for the cell-wall. It exercises a peculiar principle of interference with, and regulation of, the passage of substances from within outwards and from without inwards. It is also extensible, for the cell is capable of taking up a certain amount of fluid, and as the amount of fluid in the vacuole increases, the protoplasm lining the cell-wall expands also. It is not so clear, however, that the protoplasm is elastic—*i.e.*, an extensible body returning to a state of rest when the strain is removed—for in plasmolysis the protoplasm shrivels up, and only slowly regains its former proportions. But in many cases, and probably in all, the protoplasm is contractile, and in this respect it differs

from the cell-wall. This contractility signifies, that under certain circumstances of which we at present are ignorant, the minute micellæ of the protoplasm attract each other with greater force than at other times, and hence the size of the protoplasm diminishes. It has been laid down as a distinction between the animal kingdom and plants, that the latter are not possessed of motion; this, however, is not so, for the protoplasm in plants is contractile, exhibiting movements, and probably plasmolysis is an instance of this condition.

As regards the properties of the cell-sap: it plays a very important part in the physical or mechanical condition of the cell. It is the fluid which keeps the cells in a tense or turgid condition. This condition is one of the most important factors in growth, and in the movements of motile organs in plants. Let us enquire, then, by what means this tension is kept up. When the cell is growing, if the quantity of cell-sap did not increase with it, the cell would become loose and flaccid; this quality of turgidity depends on the presence of certain substances in solution in the cell-sap. In an ordinary case of osmosis, where a membrane is placed between a strong solution of sugar on the one side and water on the other, the water passes more rapidly through the membrane than the sugar solution does: *i.e.*, the substance of the sugar has the power of attracting a certain amount of water to itself until equilibrium is established—that is, until the solution of sugar on both sides of the membrane is exactly of equal strength—and then all further current ceases. In the cell-sap certain substances exercise this same power, and attract rather more water into the cell than it can conveniently hold, and hence a distinct and important pressure is set up between the cell-membrane and the cell-fluid. The protoplasm then maintains a hydrostatic tension on the cell, and it does this in virtue of the osmotic properties of these substances held in solution in the cell-sap. What are these substances, then? The cell-sap is a fluid of very low specific gravity, nearly the same as that of water, and if we dry it, the amount of ash after its evaporation is very slight; and, this being the case, it is difficult to see how the cell-sap exercises this extraordinary

osmotic action. In the ordinary case of osmosis above referred to, there was a thick syrupy solution, viz., sugar, to account for it. The ash, on analysis, is found to consist principally of inorganic salts, such as chlorides and nitrates, and it was formerly thought that this extraordinary osmotic action was due to their presence. The presence of coloring matter and sugar will not account for it, since these are only occasionally, not universally, present, while the nitrates and chlorides are so; but recent researches have shown that these latter are present in too small quantity to exercise this power, and that another explanation must be sought. If we take a section of a plant and touch it with blue litmus solution, we obtain distinctly red or acid reaction, for in cutting the section we have ruptured a considerable number of cells, and this acid fluid is in most instances the cell-sap. This acid reaction is due to the presence of certain organic acids formed as the result of the living activity of the protoplasm of the cell, and not taken up from the exterior. They occur in nearly all the cells of plants, and it seems probable, according to De Vries, that they are the bodies to which the osmotic action and properties are due, for if we neutralize the cell-sap of cells they lose at the same time their osmotic properties, and can no longer absorb the requisite amount of water to keep the cell in the necessary degree of tension.

And now, having got a correct and accurate idea of what a vegetable cell is, and of the various properties of the several constituent parts, we may go on to enquire the method in which the first great movement of fluid in the plant takes place. First, we have then to consider what is known as the RAPID MOVEMENT OF FLUID IN PLANTS. This also possesses other names; it is known as the ascending current of the crude sap, or the rise of the sap. Under this head there are several processes included, which, for simplicity, it will be as well to consider *seriatim.*

First then *Absorption*—what is the exact method by which plants absorb their nutriment? If we take first the simplest case, viz., that of a unicellular organism swimming freely in water, we find that every part of the plant is equally adapted for

the purpose of absorption, and no particular organs are necessary. Further, everything the plant takes up for its nutrition, even the Carbonic Dioxide gas, is derived from the water which surrounds it, and consequently must be in solution in water. What is taken up by such a plant, then, is taken up in obedience to the laws of diffusion, modified by the controlling influence exerted by the protoplasmic layer lining the cell-wall; and this is true of the great majority of plants—viz., that absorption takes place through the cell-wall. In some cases, however, we find that no cell-wall is present, but simply a mass of protoplasm—*e.g.*, in the Myxomycetes—and in this case the process is somewhat different, the protoplasm simply flowing round the solid particles; and then these particles are not absorbed into the protoplasmic substance, but are merely enclosed in it, then the protoplasm acts upon them, bringing those which are fit for food into solution, and dispersing them through its mass, while those which are unfit for digestion are afterwards thrown out. This is an exceptional case, however, for the cell-wall usually prevents the direct contact of the protoplasm with the food. If there was no living protoplasm lining the cell-wall, the process of absorption would be a simple process of absorption through a membrane, in obedience to the laws of osmosis, for if we had simply a cell-membrane, osmosis would go on freely and equally in all directions, but the presence of the protoplasmic lining removes it from the physical condition of things. Thus, if we take a typical cell, the amount per cent. of salts taken up is very much less in the cell-sap than outside, if the cell be immersed in fluid. That is to say, the cell takes up the water in which the substances are dissolved more readily than it takes up the substances themselves, consequently the more dilute the solution is the greater is the amount of salts taken up. It would seem, at first, to be a waste of energy on the part of the cell to take up large quantities of a dilute solution, filter the water off, and retain the salts, rather than to take up small quantities of a more dense one; but the fact is, that dense or strong solutions are interfered with in their passage by the protoplasm lining the cell-wall, and if they were sufficiently dense and strong they

would produce that condition of the protoplasm called plasmolysis, and so upset the entire regulation of the cell; consequently it becomes a necessity that the substances to be taken up should be in the form of a very dilute solution. The difference, then, in the passage of fluids holding substances in solution through the cell-wall from a case of ordinary osmosis, is due to the living layer of lining protoplasm, which can modify or prevent the entrance of substances in solution from the exterior; thus it allows the various solutions of salts, if sufficiently dilute, to pass, while it prevents the entrance of sugar and coloring matters. Let us consider more exactly how this process of absorption is accomplished—that is to say, how the substances absorbed pass into the cell. The cell-wall, according to the researches of Nägeli, consists of micellæ surrounded by water, and the water intervening between the various micellæ takes up from the surrounding water a certain proportion of salts, which proportion is passed on from micella to micella through the cell-wall till it reaches its interior, then from micella to micella through the protoplasm to the vacuole, so that a process of what is called *fluid diffusion* goes on from the exterior to the interior of the cell; but in the course of time a condition of equilibrium is set up, and the cell-sap will contain as much per cent. of the salts as the solution outside it, and then no more is taken up.

In the case of ordinary plants, every portion of the plant is not capable of absorption, and this function is performed in them by certain special organs. The only organs of such a plant which are capable of absorbing are the leaves and the roots. The leaves, as we shall see, absorb the gaseous nutriment from the air; while the roots absorb water from the soil, or if roots are absent, their place is taken by hairs, shoots, or branches of the thallus or plant-body. The roots are not capable of absorption over their entire surface, but only by a particular part. The tip of the root is covered by a rather loose external sheath or root-cap, and this was formerly believed to be the absorptive portion of the root, and hence received the name of the *spongiole*, and this idea still lingers in many botanical books.

But the root-cap possesses no such function, and it has been shown that it is the part of the root immediately behind the root-cap, *i.e.*, the youngest part of the root, which possesses this power. The epidermal cells which cover this portion grow out, or are prolonged into, certain long thin-walled delicate one-celled hairs, which are the absorptive portion of the root, and which are well seen in the germination of the Garden Cress (*Lepidium sativum*), and of the Buckwheat (*Polygonum Fagopyrum*). The presence of these root-hairs, then, indicates that the cells of that portion of the root are young and capable of absorption; hence, if we find them to be absent, we may usually conclude that the part of the root in question has passed the stage when it could absorb. In certain Coniferae, however, these root-hairs are absent, and absorption takes place in them by the epidermal cells themselves; also in certain plants, *e.g.*, Utricularia, which float in water, no root hairs are present, but here the cell-walls are unthickened, and the whole surface of the epidermis is capable of absorbing fluid. If we pull up a strongly growing plant out of the ground, the parts of the root which are provided with hairs (neither the extreme apex nor yet the oldest portion) will be seen to be closely covered with earthy particles, which we cannot remove without tearing the hairs.

The water taken up by the roots from the soil, by a method to be presently described, is not pure, since either rain, or water containing Carbonic Dioxide gas in solution, will act upon the soil, and bring a number of inorganic salts, which are necessary for the nutrition and growth of the protoplasm of plants, into solution in it. Certain other nutritious substances however, required by the plant, are retained by the soil so firmly that water cannot dissolve them out of it. These are decomposed by the acid cell-sap which is contained in the cells of the root, and which saturates even their cell-walls, and they then pass into the plant in the form of salts of organic acids. This we can show by growing a plant in a pot, across which, at a certain height, a plate of polished marble is placed, when we find that the calcic carbonate is decomposed at those parts of the plate which are in direct contact with the roots, and a complete outline of the

whole root system is bitten or corroded upon the marble. Experimental evidence has shown that the roots, provided they are intact, only absorb gases or liquids : if the root is broken it may absorb small solid matters, but while it remains intact nothing solid enters the plant by its means.

The salts which are taken up by the plant belong to two groups :

I. Essential salts, consisting of elements forming an essential part of the organized structure, and used directly to build up the protoplasm and cellulose of the plant; these are formed of the elements Carbon, Hydrogen, Oxygen, Nitrogen, Sulphur.

II. Non-essential salts, containing elements not in any way essential or capable of replacing essential constituents. They vary according to situation, *e.g.*, Iodine and Bromine, which are found in considerable quantities in sea plants.

Between these two are a group of elements which go to form part of the plant structure also, and they are important to the plant, as promoting the chemical processes by which the conversion of the group of essential salts from inorganic compounds to very complicated organic ones takes place; as instances of these we have Potassium, Calcium, Magnesium, Iron, and Phosphorus. They are found in the ash when the plant is burnt.

It has been found that the ash of plants which grow close together in the same soil, or in the same water, may have a composition which is different in different cases, and which is different also from that possessed by the soil. Hence some have attributed to plants a certain selective or exclusive power, which they exercised by their roots, *i.e.*, that they could absorb certain matters and reject others. This power, if it exists, must be a very feeble one at most, for roots placed in solutions injurious to the plant absorb them ; and the phenomenon is capable of a much simpler explanation by the ordinary laws of diffusion. A salt which is held in solution by the medium, whether soil or water, surrounding the plant, will continue to diffuse into the cells of the roots, until a condition of equilibrium is set up between the two fluids which are separated by the membrane; and this statement is true of those substances which, being in

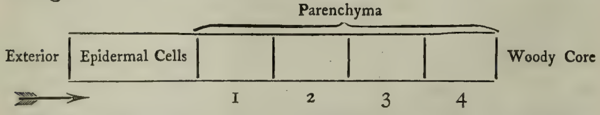
solution in water, are at once absorbed with it by the plant, and also of those substances which the plant's own agency brings into solution before absorption. If the salt is a non-essential, and is not consumed in the plant, as a necessary consequence it remains unaltered, and the state of equilibrium which is soon attained becomes permanent; hence no more of that substance will be absorbed. But if it is, as in the case of essential salts, consumed in the plant, and undergoes chemical change during its consumption, it ceases to exist in its original form in the plant, and in consequence, the state of equilibrium is being continually broken, since the plant uses it up in its life and growth, so that the cell-sap never contains an equal proportion of the salt with the fluid outside ; a demand for more is created by its disintegration, and consequently fresh supplies of it are being continually taken in. Since the chemical changes which go on differ in different plants, it is possible to account in this way for the variety in the composition of the ash of plants which have grown side by side. Water holding salts in solution is principally, if not entirely, absorbed by the roots. What, then, is the minute structure of a root ? and what is the exact method by which plants absorb this liquid ?

In a transverse section of the root of a Monocotyledon, such as Iris, seen under the microscope, covering the exterior we find a layer of epidermal cells, some of which are prolonged into root-hairs ; inside this layer are parenchyma cells of more or less rounded form, with thin walls ; in the centre we find a sort of core of narrow long cells, generally with very thick walls which are altered chemically as well, for they consist no longer entirely of cellulose, which is the normal constituent of the cell-wall, but of a modification of it, viz., lignin, or wood. This core is the fibro-vascular cylinder of the root, and it corresponds to the *wood* in a section of the stem. All the intervening space between this core and the epidermis is filled up by thin-walled parenchyma tissue.

In what manner then do the roots absorb ? The soil is not dry, at least never completely so, for we find moisture present even in sand, and this moisture so universally present is not

present locally, and does not remain in one part when put there, but permeates through the whole of the soil, and diffuses itself equally. The soil then consists of minute angular fragments, with gaps between them which are filled with air.

Each solid particle of soil is surrounded by a film or layer of water, held there by attraction—thick, if the soil be wet, thin, if it be dry—and which we may *artificially* remove altogether. The root-hairs wriggle their way among the particles, and come into close contact with them, and with the moisture which adheres to them. These root-hairs absorb water in the same manner as a unicellular organism does, by virtue of the osmotic properties of their cell-sap, which contains acids, and salts in solution. The soil also possesses moisture containing salts in solution, but in a very dilute solution, much less dense than in the cell-sap of the plant itself. These are separated by a permeable membrane, the cell-wall, and by the protoplasm, which, as we saw, does not prevent the passage of a weak solution, but only prevents the passage of a strong one. Accordingly, the previously existing condition of equilibrium is broken, and the weak solution passes into the cell-sap of the epidermal cell, while the strong solution in the cell-sap cannot pass out in turn, because of the restraining action of the protoplasm, so that a process of *endosmosis* apparently takes place. Let us suppose the cell-sap, in all the parenchyma cells intervening between the epidermis and the central core, to have been originally of the same strength.



The water taken up into the epidermal cell, by its hair-like prolongation, from the soil has rendered its cell-sap weaker than that of the parenchyma cell numbered '1' in the diagram; consequently a process of endosmosis again goes on; the cell-sap of the cell '1' taking up water from the cell-sap of the epidermal cell, until equilibrium is established between them, and thereby becoming weaker in turn than the cell-sap of cell

'2,' which thus absorbs in its turn, and so on for cells '3' and '4,' until a state of equilibrium being for the moment established between cells '3' and '4,' the fluid makes its way to the central core. By this time the epidermal cell, having its cell-sap rendered stronger through the removal of its absorbed water by cell '1,' takes more from the soil, which in like manner is passed on as before. Hence water is being continually absorbed from the soil by the root-hairs, and passed on from cell to cell through the parenchyma, by a process of endosmosis. But when we come to the passage of the fluid from the thin-walled parenchyma tissue to the cells of the thick-walled woody core, a difficulty arises, since the cells of the latter contain air, and it is not possible that this passage can take place by an ordinary process of diffusion, for in the case before us we have air on one side of the cell-wall, and a liquid on the other, whereas diffusion requires the presence of two liquids, one on either side of the separating membrane. The explanation is, that as the fluid is taken up by the parenchyma cells from without, through the medium of the root-hairs, these cells become turgid, and in virtue of this, by the osmotic action of their cell-sap they take up more water than they can possibly contain—or, in other words, the osmotic activity of the cells is so great that it is in excess of their cubic content; they become in consequence gorged with water, and in this manner a hydrostatic pressure or tension is set up, and filtration takes place into the cells of the central core. Filtration differs from diffusion in that it can take place where there is fluid on one side only of the separating membrane, and air on the other. We can show that water exists in the cells or vessels of the central core, by putting a damp log on the fire when we find that fluid and air bubbles come out. The vessels are simply formed by rows of cells placed vertically one above another, the partition walls of which have become absorbed; afterwards the cell-walls of these vessels so formed undergo chemical change. Next we have to enquire what becomes of the water when it has found its way into the vessels in the way described : in order to do this we must understand the *structure of leaves*, and something also concerning *transpiration*.

A leaf consists of a flattened out sheet of parenchyma tissue, composed of cells of various form, through which at intervals run fibro-vascular bundles, constituting what we know as the venation of the leaf; in some leaves we find a central large fibro-vascular bundle, or *midrib*, from which the other bundles, called *veins* or *nerves*, are given off, like the barbs from the quill of a feather. These again give off smaller branches or *veinlets* in their turn, in a like manner, which are connected with one another by minute branches, so that we get finally a very complex reticulum or network formed. In other leaves there is no such central midrib, but several large bundles termed *nerves* enter the leaf, and traverse it running parallel to one another. These are simply connected by cross branches at intervals. This sheet of parenchyma, known to botanists as the *mesophyll*, and the cells of which contain green coloring matter, is covered both on the upper and lower surface, by a sheet of epidermis, which is usually only a single layer of cells in thickness, to protect it. The cell-walls of these epidermal cells have become chemically changed; they have become cuticularized, that is to say, they still retain their elasticity, but they can no longer be permeated by water, nor will they swell up under its influence; when this change takes place all distinction between the outer boundaries of the constituent cells ceases, and a continuous sheet of protective cuticle covers the whole surface of the leaf.

This sheet is broken at certain intervals by apertures which are known as *stomata* or mouths. These stomata are as a rule much more frequent on the lower surface of leaves than on the upper. They consist of a central aperture or space surrounded by two or sometimes four cells, which are firmly united at their extremities. This central space can be opened or closed according as these cells, which are called the *guard cells* of the stoma, and contain chlorophyll, are turgid or flaccid. If the guard cells are flaccid, with no considerable quantity of fluid, that is to say, if they do not contain as much water as they can, their tendency is to come together, and so close the stoma. If the guard cells take up more water, so as to become tense and turgid, they must increase in size, and so tend to separate

from one another: if they were free, each would become spherical; but since they are fixed at the ends, they can only bulge out at the sides—that is, increase their curvature, for they cannot increase in length. This they do, and the stoma tends to open. Such a condition of things would be the case if the guard cells were free and isolated, but it is not that which ordinarily obtains. The guard cells, as we saw, are placed at intervals among the ordinary epidermal cells of the leaf, from which they may be distinguished both by their form and by their containing chlorophyll, which the ordinary epidermal cells do not. Their behaviour therefore is influenced by the aggregate behaviour of these epidermal cells, of which they only form a small part. When all the epidermal cells are turgid the guard cells tend to swell apart and open the stoma, but this is prevented by the turgid cells of the epidermis, which, since they occupy more space, tend to push them together. Of these two opposing forces, the influence of the epidermal cells is the greater, and consequently, when the guard cells are in the greatest degree of turgidity, the stoma is closed. When evaporation is going on, the cells of the epidermis contract, and fall apart, while the guard cells of the stoma become flaccid and tend to fall together, but are pulled apart by the superior opposing force of the epidermal cells. The factors acting upon the process of the opening and closing of the stomata are thus not single, but the resultant of a number of forces.

The parenchyma tissue of the leaf consists of two kinds of cells :—

First, oblong cells, which touch on all sides, and are packed closely together so as to leave no intercellular spaces. These occur immediately below the layer of epidermis covering the upper surface of the leaf, they are placed perpendicularly to the surface, and they are sometimes known as the *palisade layer*.

Secondly, irregularly branched, more or less rounded cells, which of course, in consequence of their shape, cannot touch at all points, but leave spaces intervening between them, which are known as intercellular spaces. These cells, like those of

the palisade layer, contain chlorophyll. They form the lower and larger half of the leaf substance.

The stomata which we have mentioned communicate directly with the intercellular spaces which are nearest the lower surface. We shall presently see the functions of all these parts, in connection with the upward movement of fluid in the stem : but first a few words about *Transpiration*.

Every portion of a plant which is exposed to the atmosphere, and which is not covered by thick layers of cork, *e. g.* the stem, or by cuticle, *e. g* the leaves, both of which are equally impervious to air or water, is constantly giving off enormous quantities of water vapour into the air by evaporation. This exhalation or loss of watery vapour from any part of a plant is known as *Transpiration*, and it takes place, as I have said, wherever a cell is exposed to the air. Water-weeds for example, such as Potamogeton, when dragged out on the bank, very quickly shrivel up, and lose their water faster than aerial plants do : this is due to the fact that the epidermis is not cuticularized in them, and consequently transpiration takes place from the entire surface of the plant. Owing, however, to the principal parts of plants being covered either by cuticle or by cork, it is carried on for the most part by means of certain openings, viz., the stomata of which we have just spoken ; these stomata occur on all parts of the more highly organized plants which are above the ground, viz., on stems, leaves, and the petals of flowers ; they extend also very far down in the vegetable kingdom, thus we find them among the Mosses and Liverworts (*Hepaticae*). Below this last named group we find no trace of them, but there is no need for them, since all the cells are more or less in contact with the air or water, and the exchange of gases can take place through their walls.

The leaves are the principal organs of transpiration, because in them, as we have seen, the stomata open into the intercellular spaces, which are bounded by the cell-walls of many cells. Transpiration does occur also, however, in stems provided with stomata and epidermis (herbaceous plants), or even where the epidermis has become transformed into cuticle, if the

internal tissues are placed in communication with the exterior, by means of channels of communication. We have an example of these in the 'lenticels' found among the cork cells of the outer layer of the bark, which are in reality the stomata of the cork layer of the stem, and each frequently, if not always, corresponds to a primitive stoma of the epidermis, whose place the layers of cork have taken. Apart from the stomata and lenticels, there is little transpiration of fluid ; for the leaves, as we have seen, though thin, have the exterior layer of their epidermal covering rendered impervious to water, so that exhalation of watery vapour can only take place from the unthickened cell walls of the cells composing the mesophyll, and bordering the intercellular spaces with which the stomata communicate. If we place a stem bearing leaves under a bell-jar at a sufficiently high temperature, the glass will soon be covered with drops of water, in consequence of the watery vapour, which is given off by the plant, being condensed.

Transpiration is not merely a process of evaporation, but is something beyond that. Evaporation is dependent on certain external influences, such as the amount of heat and the degree of saturation of the air ; it will increase as the temperature of the surrounding air rises, and the degree of saturation by moisture consequently decreases. Transpiration is influenced by the same circumstances ; its amount is of necessity the greater, the higher the temperature and the drier the surrounding air ; but it is also dependent on the nature of the plant. Evaporation takes place in proportion to, and varies directly as, the actual amount of surface exposed. The amount of transpiration is dependent on the number of the stomata, and their size : hence its amount is different on the two surfaces of a leaf ; the under surface, which has the greatest number of stomata, having also the largest amount of transpiration. That transpiration is not, however, absolutely dependent on the number of the stomata, is shown by the Lime-tree (*Tilia Europaea*) where on the upper surface of the leaves the proportion of stomata in a square millimetre is *nil*, and on the lower surface the proportion is sixty, while transpiration takes place from the upper surface in the proportion of twenty, and from the lower in the

proportion of fifty; also in the Dahlia, where the proportion of stomata on the upper surface of the leaf is twenty-two, on the lower surface thirty-three, or as 2:3, while the degree of transpiration on the upper surface is 50, and on the lower surface 100, or as 1:2. In the Deadly Nightshade the proportion of stomata on the upper surface is 5·5 to 10 on the lower surface, and the relative quantity of water transpired is as 48:60. Recent results have shown further that the quantity of water exhaled is greater in the *same* proportion as the number of stomata is greater. Those points which particularly affect the degree of transpiration in plants may be grouped under two main heads.

I. *External influences.* Of these the first is the presence of light, which, however, is so usually associated with a rise of temperature, that it is a matter of difficulty to isolate them. In the dark, the stomata of most plants are almost or quite closed, hence very little watery vapour can be then exhaled, and if a low degree of temperature be present at the same time, the process of transpiration may become slow, or even cease altogether. The immediate bearing of this statement will become evident when we come to consider root-pressure The stomata of most plants are, on the contrary, most widely open in the light, especially if it be bright, even if the temperature be low. Hence, according to the careful experiments of MacNab, increase of light, apart altogether from, and independently of, the elevation of temperature, has a distinct influence on the amount of transpiration which it increases. Increase in the amount of humidity of the air also affects it in two ways; 1st, it acts by simply checking the process of evaporation, and 2ndly, it acts on the stomata, causing the guard and epidermal cells to swell up and become turgid, and thus diminishing the size of the stomata, that is to say, causing their closure.

We may consider, together, the effect produced by variations in the moisture of the air surrounding the transpiring organ, and that produced by variations in the temperature of the air; for each of these conditions is so dependent on the other that it is impossible altogether to eliminate its influence

and consider it apart. If the humidity of the air is very great, *i. e.*, if the air is at or near its point of saturation, the amount of water given off by the plant is very small, *i. e.*, transpiration is practically absent, provided always that, as is usually the case, there is no important difference between the temperature of the plant and that of the air outside. But in a saturated atmosphere, variations in the temperature of the air may occur, so that the temperature of the air rises above that of the plant, and under these conditions, transpiration will go on to a perceptible, though to no very great extent, although the air is saturated with moisture. Under ordinary circumstances, however, when the degree of humidity of the air is moderate, the amount of transpiration is affected by the degree of humidity, since if the air becomes moister the amount of transpiration becomes less, and *vice versa*. Variations in the degree of humidity of the air are, however, affected in their turn by changes in the temperature, so that every change in the temperature of the air produces either directly or mediately an effect on transpiration. When the degree of humidity of the air is high, it tends to reduce the amount of transpiration in the plant, but when the temperature of the air is high, that is to say, when the air is hot, it tends to promote transpiration and render its amount greater. On the other hand, the cooler the air is, the less will transpiration go on.

To return for a moment to the influence of light on transpiration. We have seen that this factor has an important bearing on the opening and closing of the stomata; and when we come to speak of their function later on, we shall see these stomata exert in turn an important influence upon transpiration;—hence, through their mediate agency, light exercises an important influence on transpiration.

From experiments conducted by Hales more than a century ago upon many plants of the Sunflower (*Helianthus annuus*) it was found that in a day of twelve hours the maximum loss of water by a plant was thirty ounces, and the mean loss twenty ounces, while in a night of the same duration the mean loss was three ounces. This shows us that while the amount of water

transpired during the day, *i.e.* in the light, is very large, the amount transpired during the night, *i.e.* in the dark, is very small indeed. In this case the influence of light on transpiration is mainly due to the widely open stomata, though in part to the warmth of the air.

But light has probably a *direct* influence upon transpiration, altogether apart from its effect on the stomata ; at least we have some observations on record which seem to show that this is the case, although it is extremely difficult to get the action of light as *light* solely, and not accompanied by any variations of temperature induced by it. These experiments were carefully performed on plants kept in a moist and nearly saturated atmosphere, *i.e.*, under conditions which prevented any change in the temperature or humidity of the air around the plant. It was then found that under such conditions the stomata remained open both in the dark and in the light, so that the effect of light upon these structures was thereby eliminated ; and further, it was observed that exposure to light increased very much the amount of transpiration of the plant as compared with the amount of transpiration of the same plant for an equal time in the dark.

The nature of the substances present in the water taken up by the roots, and so introduced into the plant, materially affects the amount of transpiration going on in the leaves.

Movements of the air produce an influence in a twofold fashion—first, by promoting evaporation, and, second, by shaking the parts of the plant, *e. g.* the leaves and branches, thereby promoting transpiration. Thus, if an ordinary branch be taken and violently shaken for a minute or two, the leaves become flaccid and hang down for a considerable time, as if they had been supplied with too little moisture. The reason of this is that the mechanical stimulus produced by shaking the leaves causes excessive transpiration. This is an interesting point in connection with the attractive power of the living protoplasm for water, for by shaking this attraction is diminished, and it allows the passage of water through it to take place in consequence more readily than is usually the case.

II. *Internal Causes.* Transpiration varies in quantity ac-

cording to the special organization of the plant and of its separate parts. First: *Texture of the plant.* The stems of most woody plants and trees are, as we have seen, almost entirely prevented from transpiring by thick layers of cork; and transpiration is small in such stems and leaves as are covered with a thick cuticle, such as the stems of Cacti, the leaves of Agave and of Begonia, and hard evergreen leaves. The leaves of Agave and Begonia, when cut off from the parent plant, wither slowly, and can live for a long time without any water, since evaporation is very slow, as the texture of the leaf almost eliminates transpiration. These plants can also thrive in a very dry soil. Tender leaves, on the contrary, in which the cuticle is but slightly developed, as *e. g.* those of the Tobacco (*Nicotiana tabacum*) and the Pumpkin, wither as soon as they are removed from the plant, or if the soil becomes too dry. This condition is also seen in many aquatic plants, such as the Potamogetons, where the texture of the leaves is very flimsy and weak, and as a consequence evaporation on exposure to the air is very rapid indeed. Secondly, *the age of the leaf*, apart from its texture, exercises a very important influence on the activity and amount of transpiration in a given time. This has formed the subject of recent investigations by an Austrian observer, Von Höhnel. From these researches it appears that we can represent the amount of transpiration at the various periods in the life of a leaf by means of a curve. At the time of its first appearance, the amount of transpiration attains an expression very considerably greater than we find to be the case at any subsequent period in the history of the leaf. From this point the curve descends, indicating a diminution in the amount of transpiration; after a time, however, the curve begins to rise again, indicating an increase in the amount, though it never attains its initial height, and then at length it finally sinks gradually, indicating a marked decrease. The meaning of this curve is very interesting. In their initial condition the leaves had no cuticle and no stomata:—consequently, whatever transpiration took place did so through the closed cell-walls, forming the external surface of the epi-

dermal cells. This we may call the period of *Epidermal transpiration*. As the leaf grows older this epidermal transpiration becomes interfered with by the gradual development of the cuticle; hence we get a diminution in the amount of transpiration, and the curve, as we saw, falls. But simultaneously with the production of cuticle we find the development of the stomata taking place, and at the period of the history of the leaf when the cuticle has reached the highest point in its development, the stomata have already begun to play an important part in the function of transpiration which, in some measure, compensates for the diminution of its amount occasioned by the cuticle, and so we find the curve rising again. This period may be called that of *Stomatal transpiration*. The amount at the maximum of this period is never so great as at the maximum of the period of epidermal transpiration. As the leaf grows older the amount of transpiration becomes less and less, and the curve gradually and permanently falls. These experiments show us the importance of considering the *age* of the leaf as modifying transpiration, and they also teach us what we shall have to consider more fully hereafter, the great importance of the stomata in relation to the function of transpiration.

Next let us enquire—Do we find any definite sequence of rise and fall in the amount of transpiration taking place within the twenty-four hours, or in other words, is there any *daily periodicity* of transpiration, such as we shall subsequently find occurs in the case of the root-pressure? I can only say, in passing, that all we do know is that in the daytime the amount of transpiration is much greater than it is at night, but we have not at present materials for constructing a definite sequence to express this difference with points of maxima and minima. Both light and external circumstances affect the transpiration directly, and hence whatever periodicity is present may perhaps be due to these forces, and not to any internal inherent periodicity in the plant itself, such as we will find in the case of the root-pressure. Yet, while we have no direct proof that an inherent periodicity does exist, there is some reason for thinking that it

may do so, though the existing periodicity is so sensitive to the action of external stimuli that it becomes very difficult to eliminate their influence. The transpiration of watery vapour in plants is precisely analogous to the transpiration of vapour in the respiration of animals. The physiological import or significance of transpiration with regard to the general economy of the whole plant may be briefly stated, as follows :—There is very little doubt that transpiration exercises an important influence on the amount of absorption by the roots, although there is no direct relation between these two functions. The loss of water by transpiration from the plant must be replaced, or else fading speedily ensues. Under normal circumstances it is replaced by the water containing salts in solution, which is absorbed by the roots from the soil being conveyed to the leaves. The greater the loss by transpiration, the greater will be, therefore, the amount of absorption, and, consequently, the greater the amount of salts in solution taken into the plant, and in this way the passage of an enormous quantity of water through the plant assists and promotes the absorption of water containing substances in solution from the soil by the roots.

Transpiration, then, causes a varying flow of water bearing certain nutritive substances; and as transpiration takes place in the leaves which are situated at one extremity of the axis of the plant, and the great organs of absorption, as we have seen, are the roots, which are placed at the other end, the general movement of water from the roots to the leaves through the stem is an upward one, and used to be spoken of as the rising sap. It is determined by two principal causes: 1, suction from above, due to transpiration ; 2, pressure from below, due to the hydrostatic pressure exercised by the parenchyma cells of the root. The temperature of the soil varies less than that of the air ; consequently the water taken up is at a more or less uniform temperature, and hence the rush of this water up the stem produces the effect of equalizing the temperature of the plant. Transpiration also lowers the temperature of the surface parts of the plant in hot weather, just as, *e. g.*, the evaporation of spirit on the hand produces a sensation of cold, since the heat

required to convert it into vapour is derived from the skin, so evaporation takes heat from the parts in order to enable it to take place. The process of evaporation consists in the removal of pure water; hence, although water containing salts in solution is absorbed by the plant, only pure water is given off, and an accumulation of salts takes place in the plant. The loss of water caused by transpiration very materially affects the amount of water in the plant at any moment, and so indirectly affects the growth of the plant. For the growth of each individual cell is due to a condition of turgidity, and if this condition ceases to obtain, growth ceases also. If the transpiration is then excessive, and the plant loses more water than it can take up, the cells of the plant lose their turgid condition, and so the growth of the plant is considerably retarded. Transpiration, doubtless, exercises an important influence by causing what is known as the *negative pressure* in the wood, the reason of which I hope to show presently.

Now as to the *Function of the Stomata.* It was formerly thought that the stomata, through which transpiration for the most part takes place, acted as protective regulators of the amount of fluid exhaled : thus it was said that when the plant was transpiring very actively, the stomata remained closed, so as to shield the plant and prevent it from losing too much moisture : when, on the other hand, the atmosphere was nearly saturated with moisture, so that there was little evaporation, and the light was dull, the stomata opened, because then no harm could come of a free passage into the leaves being left open, for moisture to come out. I said that this would be the case if the stomata were isolated; but that since they are placed among the cells of the epidermis, owing to the action of these cells overcoming that of the guard cells of the stomata, the total result was, that when the temperature was highest and the sunlight brightest, and as a natural consequence the amount of transpiration at a maximum, the stomata were always most widely opened—precisely the reverse of what ought to occur according to the old theory ; so that it is apparent that there is no direct provision in the stomata for checking the amount of

transpiration.* When the air is very damp, and near to its point of saturation, or when the light is dull, or it is night, the stomata are closed, and the guard cells remain side by side. Some other explanation, then, of the function of these stomata, than the old one that they are *regulators* of the amount of transpiration, must be sought. Have the stomata, then, much importance as regulators of the absorption of gases, *i. e.*, do they materially assist the leaf in taking up Carbon Dioxide from the air? for the conditions under which the stomata are most widely opened, viz., dry air, high temperature, and intensely bright sunlight, are also those under which the greatest supply of Carbon Dioxide is taken up by the cells of the leaf. It was thought until recently that they were of great importance, and it was believed that the wide open condition of the stomata had a distinct relation to the ready passage of Carbon Dioxide from the exterior air into the intercellular passages present on the lower surface of the leaf, whence the parenchyma cells of the mesophyll absorbed it with great activity; since the cells bounding these passages, which had absorbed as much of the gas as they could, when they were robbed of their store continually by

* The opinion stated in a previous part of this essay—viz., that the independent action of the guard cells, under conditions favouring transpiration, was to close the stomata, but that they were restrained from doing so through the greater force produced by the flaccid condition of the other epidermal cells exerting a stronger influence upon the guard cells than their own flaccid condition does, and that, consequently, the open state of the stomata, under the conditions of bright sunlight and high temperature, was due to the total or resultant action of two opposite and non-concurrent forces—was held until very recently. But it has lately been shown that the action of bright sunlight, which increases the amount of transpiration, also causes separation, not closure—turgidity, not flaccidity, of the guard cells themselves; and hence opening of the stomata. Von Mohl attributes this to the mechanical stimulus of light inducing the formation in the cell-sap of the guard cells of osmotic substances capable of attracting great amounts of water; other observers think that the action of light is to increase the resistance of the living protoplasm in the cell to the loss of water from it. At present the balance of evidence is about equal on both sides; perhaps it slightly inclines more to favour the last. Whatever be the view taken, however, the fact is plain that the action of the guard cells under sunlight is concurrent with that of the ordinary epidermal cells, though the two actions are due to exactly opposite conditions—the former to turgidity, the latter to a flaccid condition—and it is owing to their combined (not mean) action that the stomata remain widely open.

the more internal cells in their immediate proximity, could absorb further supplies rapidly from the store at hand in the intercellular passages. Boussingault has very recently shown, however, from comparative experiments made upon a large number of leaves, between the amount of absorption of the upper surface of the leaf, which has but few stomata, and the lower surface where stomata are present in large numbers, that the upper surface absorbs more actively, and at the same time takes up a much larger quantity of Carbon Dioxide gas, than does the lower surface. Hence the stomata would appear to have no part of importance to play in the absorption of gases by plants, which must take place, then, directly through the cuticularized cell-walls of the epidermal cells. These latter are permeable by dry gases, and so there is no obstacle offered by them to the absorption of gases by the cells of the epidermis ; it is only to the passage of watery vapour that the cuticle offers any resistance. In so far as the stomata are concerned in any way with the interchange of gases by the plant, they seem to be channels of exit for these gases, for the stomata open very readily when slight pressure is brought to bear on them from within, while they do not open so readily to pressure applied from without. Pressure from within may be brought about by the gases in the intercellular spaces being expanded, if the temperature increases and becomes high ; under the influence of this pressure the stomata readily open, and permit the gases to escape into the surrounding air.

Since then the only function with which the stomata are concerned, apart from this comparatively trivial one of favouring the exit of gases, is that of transpiration, let us see what the real influence of their action is upon it. We have seen that the opening and closing of the stomata are due to variations in the condition of turgidity of the guard-cells, and also that the action of bright sunlight and warmth, which increase the amount of transpiration, cause also separation of the guard-cells, and hence opening of the stomata. When transpiration is most vigorous, the plant is likely to lose the greatest amount of water, and hence the object and use of the stomata is *to facilitate and promote the escape of water in the form of vapour from the cell-walls of the leaf-cells of plants.*

We have also seen when transpiration is not active, the stomata are not required to be open, and hence they are found to be closed. An adequate amount of transpiration is very important to the plant, because it is due to this that a supply of inorganic substances are absorbed in solution. These substances we saw could only be taken up in very small quantities, and since a very large supply of them is required in the plant, it follows, as a necessary consequence, that a very considerable amount of transpiration is needed to supply an adequate amount of nutrition to the plant. Further, as we shall see, the formation of starch from the Carbon Dioxide, absorbed by the cells of the leaf, independently of the stomata, is dependent on the absorption of certain inorganic salts, as *e. g.* those of Potassium, by the roots; and hence it is necessary that while the process of absorption of Carbon Dioxide is going on actively, under the conditions of bright light and warmth, a large quantity of these salts should be absorbed at the same time; and this can only take place by means of sufficient transpiration at the leaves, through the widely open stomata.

As to the method of transference of fluid from the vessels of the woody core to the different parts of the plant, or in other words, as to the *course* of the rising sap, different views have been entertained. The chief structural elements composing the central core of the wood or prosenchyma, are vessels and fibres together with ordinary parenchyma cells; and the question arises, does the water rise uniformly through all of these, or only through some of them, and if so, through which? At first sight, the cavities of the vessels would appear to be the most natural channel for the water, since they are open from one end of the plant to the other, and the old idea was that in them the water was conveyed, that they acted like blood-vessels, and contained fluid. In spring, the cavities of the vessels do contain water, but as summer comes on and the leaves expand the amount of water gradually decreases, and they become filled with air, and when transpiration has really set in the whole cavity is occupied by air, so that in summer, when transpiration is most active, and consequently the amount of fluid passing to supply the loss which it occasions is greatest,

no water is present in the cavities of the vessels;—consequently it is erroneous to compare them with the blood-vessels of animals, and another explanation must be sought. It is only in special cases that the vessels do contain water, for, as a rule, they contain nothing but air.

By introducing various staining fluids into the plant, such as chloride or sulphate of aniline, we apparently get some evidence that the course of the current of liquid is confined to the wood. For all the woody elements of the younger portion of the wood of the plant through which this staining solution passes will be stained a bright yellow or deep brown colour by it. This solution, then, stains the wood-vessels, and thus affords a characteristic test for lignified tissue. But though this evidence appears at first satisfactory, we must not overlook the fact that the solution of aniline might pass up through other cells as well as through those of the wood, but yet not stain them, because they are not lignified; and, consequently, if we relied on it for our conclusions alone, we might be led into error.

The pith, which seems to be, next to the cavities of the vessels, the most feasible channel, cannot afford a means for its conveyance, because in all cases it remains exceedingly small, and the larger the plant becomes, the smaller proportionately is the amount of pith; so that except in the very young condition the consistence of its cells becomes either dried up or inert; and in many stems, after a few years, it ruptures and either completely disappears or remains in the form of interrupted thin shreds of tissue. Further, some observers have removed the pith, and shown that after its removal the plant flourishes as well as it previously did.

The medullary rays, which are strands of parenchymatous tissue, running radially from the pith to the bast layer of the bark, only occur at intervals, and do not extend along the stem, consequently they are of no value as a channel for the upward current of water; and the same thing may be said of the intercellular spaces, which habitually contain air, and of which there are very few in the wood. Does the upward current then ascend by the bast layer of the bark (*phloem*), or by the fibres of the

wood proper (*xylem*)? for only these two alternatives are now left us. If we take a plant which, when fully grown, has no continuous pith in the centre of the stem but only a fibro-vascular mass surrounded by cortex, *e.g.*, a tree; and if we cut into it all round the stem in the form of a complete ring, right down to the interior of the layer whence annual additions are made to the wood and bast, viz., the cambium, so as to remove all the tissues for the width of one inch, and separate the cortex of the upper part of the tree from that of the lower, but leave the xylem bundles themselves untouched ;—now, if the water rose by means of the bast, the tree should fade, because we have cut off the supply which filled up the loss due to transpiration. But the upper part of the tree, bearing the leaves, does not fade, but continues to grow; the leaves continue fresh and green, and fresh leaves are put forth; the removal of the ring of cortical tissue, then, does not interfere with the passage of liquid to the leaves, and the only connection which can exist between them and the roots is in the woody tissue of the plant, and hence the water which passed from below upwards must have undoubtedly passed through the wood. It appears then, from elaborate researches, that the vessels and fibres of the wood take up the water absorbed by the roots and pass it on in the thickness of their cell-walls, which consist, as we saw, of minute solid particles separated by areas of water.

But the question arises, how can liquid actually travel *in* the substance of the lignified cell-walls? To answer this we must understand the precise nature and properties of a cell-wall when lignified. These properties are not those of the ordinary unaltered cellulose membrane; for a cellulose wall has the power of taking up a considerable amount of water between its micellæ, and of swelling up to a considerable degree. When it becomes changed into one composed of lignin, however, it loses this power of swelling up, and can take up a small amount of water between its micellæ, but only a relatively small amount, and it attains its point of saturation more rapidly than in the case of the ordinary cell-wall. It is not impermeable to water, on the contrary it takes water up readily, and very readily parts with it again, but does not

attempt, in any way, to retain and hold it as a cellulose wall does. It only takes it up and gives it up again in very small quantities, however. The ordinary cellulose cell-walls, on account of their property of levying black mail upon any fluid that passes into them, and retaining a considerable quantity of the water in themselves, are not good conductors of fluid. The lignified cell-wall, on the other hand, is a good conductor, as it must pass on whatever fluid it gets, since it cannot absorb it into itself. A very slight pressure, then, on the part of the parenchyma cells of the root, is sufficient to make the lignified cell-walls take up water from them, and when this fluid has got into the lignified wall, it exists there in a very mobile condition, and can be readily passed on.

The fluid in the walls of fibro-vascular tissue in the leaves, is constantly being drawn upon by the parenchyma cells of the leaves which are actively transpiring. In consequence of this, the vessel walls become poor in water, and exert a drawing influence on the water in the walls of the remainder of the vascular system ; this influence extends down the leaf-stalk into the branch, and thence into the stem, and finally to the vessels of the root. If the fluid which exists in the lignified cell-wall, was in a similar condition to that of the water in a cellulose one, the supply of fluid to meet the demand created by transpiration could not be maintained with sufficient rapidity, but since it exists in a condition in which it can easily be passed along, this enables the necessary supply to be kept up through a long branch.

If an ordinary branch of pinewood, a yard in length, be taken, and the surfaces of its two ends having been rendered perfectly smooth, be then carefully dried, and after this a little moisture is spread on the upper surface by means of a brush, at the same moment as the application is made, a distinct appearance of liquid poured out at the other extremity will be observed. From this simple experiment we can derive some idea as to the state of things existing in the living plant, and thus we see that a withdrawal of water, however slight, at one point, is accompanied by an absorption of water at another. The liquid in the lignified cell-walls forms then an unbroken column, from the leaves down

to the roots, intercepted, but not interrupted, by the solid micellæ; and the whole question of its passage in these is a simple question of hydrostatic equilibrium;—the smallest disturbance, causing withdrawal of water at one point, is sufficient to cause a rush of water at another to supply its place.

That the lignified cells of the wood serve for the conduction of water, is also confirmed by the fact that submerged water plants, which can have no transpiration, and lose no water at their surface, have no lignified elements in their wood. In these plants we find that the fibro-vascular system is very feebly developed, and almost absent, although in land plants closely allied to them we find a well-defined fibro-vascular system. This mode of conduction of liquids is confined then to plants having a well-developed fibro-vascular system; and as the physiological significance, and one of the uses, of a great fibro-vascular system, is to afford a supply of the water absorbed by the roots to the leaves, we find it most developed in plants having a well-developed leaf system.

So then, at the leaves, we find a considerable demand for watery vapour which must be supplied from below; this watery vapour passes between the micellæ in the thickness of the woody walls of the vessels, and makes its way to the cell-walls of the leaves. The fibro-vascular system of the plant when the plant is entire is a completely closed one, as are the blood vessels of animals; under ordinary circumstances we find no communication between the external air and the interior of the fibro-vascular system. For if we make a section of the stem of an actively transpiring plant under mercury, we find that upon section the mercury is absorbed into it (or better still, use solution of a salt of lithium, taking care to make the section under the surface of the fluid); hence, the air in the cavities of the vessels is at a lower pressure than that of the atmosphere, that is to say, it exists at a minus or *negative pressure*. This experiment, then, demonstrates the truth of the statement that the vessels must be completely closed, otherwise there would have been an equality of pressure between air in the vessels and the external atmosphere.

A negative pressure, then, indicates that a marked difference of

pressure exists between the air in the vessels and the external air. In what way is this negative pressure brought about? First let us take as an example for our consideration a low-growing plant, such as Alchemilla, which in the night transpires very little water and absorbs a good deal—so much so, that the water is forced by filtration under pressure into the vessels, and becomes exuded as drops of water along the margin of the leaves in the morning by means of special arrangements known as *water-pores*, of which more hereafter. During the daytime transpiration becomes active, and as it proceeds the water is withdrawn from the cavities of the vessels to meet the demand, and consequently these cavities become empty. Transpiration has the effect, then, of tending to produce a vacuum, for a small amount of air present in the cavities along with the liquid becomes much expanded or rarefied, and exists at a lower, more diminished pressure than that of the external air, *i. e.*, at a negative pressure. When night comes again, the activity of the root absorption forces water into the vessel cavities and compresses the rarefied air so as to bring it back to a pressure equal to that of the air outside. What happens to this plant daily, takes place also in large plants such as trees, yearly. In the spring of the year, before the development of the leaves has taken place, the cavities of the vessels contain a considerable quantity of water, and also some air at normal pressure. When transpiration sets in and becomes active, this water is gradually withdrawn, and the remaining air expands, owing to the creation of a partial vacuum, and so it comes to have a lower pressure than that of the external air, and this is the condition in which we found it existing upon section in the summer. The presence of this negative pressure demonstrates the fact that the cavities of the wood-cells and vessels are completely shut off from the external air, and have no direct communication with it through the openings of the stomata, as was formerly believed; for if such an opening to the exterior did exist, this negative pressure could not be present.

When we submit sections of the parts of the plant to microscopic examination, we can see how this complete closure is brought about. We shall then find that the vessels of the wood

are covered by layers of cells which protect and shut them off entirely from the influence of intercellular spaces lying more superficially. Thus, in the root, the endodermis or bundle-sheath forms a compact complete layer round the fibro-vascular tissue and cuts it off from the intercellular spaces existing in the cortical parenchyma. This endodermis is present also in some stems in a like position, or if it is absent its place is taken by layers of thickened closely-packed cells which have the same protective function. In consequence of the existence of this negative pressure in the cavities of the vessels, there is a passage of air by diffusion from the surrounding tissues into the cavities of the cells and vessels of the wood. For this negative pressure tends to exercise an attraction for the gases in the other tissues, and to draw them towards the vessel-cavities, thereby setting up currents; but this attractive power is never sufficiently great to bring the air in the vessels to the normal pressure of the air outside. This negative pressure has also an important influence in promoting and rendering more easy of accomplishment than it would otherwise have been the entrance of water from the parenchyma cells adjoining the fibro-vascular cylinder through the walls into the cavities of the vascular system, where it is seen in the case of pruning a Vine in spring. The passage of fluid and of gases from the wood to the stomata must take place by the cell-walls, since the cell-walls can only pass substances in the form of solution. The watery vapour is simply given off as watery vapour from the external moist surfaces of the wood-cells or vessels, and it may be deposited as drops in the plant itself, *e. g.*, in the case of water found in the cells surrounding the vessels in the tops of high trees;—or it may pass out of it as watery vapour. Its course is briefly as follows:—The fluid is absorbed by the root-hairs, it passes by diffusion through the parenchyma cells of the root, by filtration under pressure from them into the vessel-walls of the root, and it is conveyed in the thickness of the lignified cell-walls of the woody tissues through the stem to the leaves, and from the moist surfaces of the parenchyma cell-walls of the leaf into the intercellular spaces in communication with the stomata, through

which it is exhaled in considerable quantities. The liquid absorbed by the roots is not forced by their osmotic activity to the leaves, but only into the vessel-walls, and thence it is sucked up in obedience to transpiration. We have still to enquire how the water gets from the vessels of the leaves, in the vessel-walls of which it exists, to the actual cells which exhale the watery vapour. These latter are not wood cells, but parenchymatous cells containing chlorophyll grains for the most part, and making up the great mass of the tissue or *mesophyll* of the leaf. Water has then to get to these from the vessels, and this is accomplished in a similar manner to the original mode of absorption of the water by the roots. The vessels contain in their walls then a considerable quantity of water taken up from below; this is absorbed by the parenchymatous cells adjoining them in virtue of their osmotic activity, which in these cells, as in those of the root, is always greater than their cubic content, *i. e.*, if the cell-walls allowed of their expanding they could take up more water ; this water taken up from the vessel-wall is then passed on from cell to cell towards the exterior by osmosis, and exhaled in the form of watery vapour into the intercellular passages, and thence through the stomata.

Hitherto we have considered herbaceous plants ; but in trees, all the vessels do not transmit fluid in their walls. The wood in a Dicotyledonous stem which increases in thickness, at length comes to consist of a central portion which is older, darker coloured, and harder than the rest, called the *duramen* or heart-wood ; and of an outer, younger, and lighter coloured portion which is called the *alburnum* or sap-wood. Of these two portions the alburnum is the only part which is active in this process and fitted by its organization to transmit fluid, and which is likewise in connection with the leaves of the year ; the duramen, on the other hand, soon dries and becomes more and more incapable of transmitting fluids, so that it takes no part in this conduction of water. This is illustrated by the vegetation of hollow forest trees, in which a sufficient layer of young wood remains within the bark to carry up the

absorbed fluids. It has been found that the careful removal of the heart-wood of trees does not prevent the supply of liquid to the branches from the roots ; but if the layers of sap-wood are removed, the upper parts of the tree die from desiccation even when the bark is left uninjured, except to such an extent as is sufficient to allow of removing the wood beneath. What advantage does the plant gain then by the exhalation of such a large quantity of water as this ? for in the Sunflower (*Helianthus annuus*) on a summer day, the weight of the water exhaled is equal to the weight of the plant itself. The answer is that as fast as water is being transpired by the leaves a demand for more is set up, and the plant takes up as much fluid as it is possible for it to do by the roots, but sometimes it cannot get enough. It takes up, not water alone, but water containing salts in solution, which are then present in comparatively large quantities in the plant for its nutrition. Transpiration is then the force by which the plant gains a supply of energy for its growth. It is greatest when the activity of the plant is greatest ; in the Sunflower, when the leaves are largest, and the temperature high, and the light intense, the stomata are most widely open, and it is just then that the largest amount of salts are needed for nutrition. The transpiration of a plant does not bear any direct relation to the amount of moisture absorbed by its roots, for under certain circumstances, as on particularly hot days, when the atmosphere is flashing with a bright light, we get a condition where the amount of transpiration is in excess of the amount of absorption, and what is known as *withering* or *wilting* of the plant occurs ; the leaves of the tree or herbaceous plant giving out more water than is taken in by the roots, so that the cells remain no longer tense but become flaccid, the plant droops, and if this condition be long continued the plant may die. If the activity of the root absorption be in any way impaired and diminished, as, *e. g.*, if the root be too much cooled, the plant withers. Again, a plant when newly transplanted droops for a time, because the roots, though they are supplied adequately with water, are incapable of taking up the requisite amount of water fast enough until

a new growth of root-hairs enables them to become closely attached to the particles of the soil, and in this case it is advisable to remove the leaves. A plant also growing in a dry soil as a habitat, if the season be unusually dry, gives out more fluid than it takes up, and soon dies. The plant, in ordinary conditions, usually takes up rather more than enough to supply the demand of transpiration, as it has also to perform the processes of growth. Weeds, also, when removed from the soil, rapidly fade and die from loss of water by transpiration. That they do not die merely from exposure of the roots is clear; if so, how could we explain the cases, such as we have presently to notice, of the withering of shoots or flowers which have been cut off from the plant? The conditions of withering are especially of interest to those who are cultivators of vines in this country, since the roots are generally outside and the stem and leaves inside the hothouse. If the leaves in the warm atmosphere within give off a large quantity of water, while the temperature is very low outside, the plant will not be supplied with sufficient moisture, because the root can take up moisture only after a certain degree of temperature has been reached.

The aerial parts of plants, as stems and leaves, are not capable of absorbing watery vapour from a moist atmosphere, or from water poured over them. We might expect that the upper surface of the leaf being exposed to rain could absorb some, but it does not;—the upper surface of the leaf is not usually provided with stomata, and is covered with a continuous cuticle, often covered in turn with wax, and so rendered waterproof. The aerial roots of Orchids, which hang down into the air, may draw watery vapour from it, as in those forms which rest on other plants for support, but obtain no nutriment from them, and are known to botanists as *epiphytes* or air plants. The roots of these plants, which are peculiarly adapted for taking up moisture from the air, are, as a rule, invested with a very special covering, known as the *velamen*, which consists of several layers of spirally thickened epidermal cells, often quite empty, which communicate freely with the external medium, and abut on the cells of the interior of the root. These velamen cells act in the

same manner as the particles of soil do, and catch the particles of water, whether in the fluid form, as from rain ; or they can condense aqueous vapour just as the particles of the soil can do, and in this manner they will draw from the air supplies of watery vapour sufficient for the closed cells of the root with which they are in contact, for the plant in this case is absolutely dependent on the water which is thus taken up. It is, no doubt, a matter of common observation that drooping plants recover their turgidity when they are wetted by dew or rain, or if the air be moist. This is the result, however, partly of an increased supply of water from the moistened earth, and partly of a diminished transpiration in consequence of the dampness of the atmosphere :—it is not the result of absorption of water by the leaves.

This phenomenon of drooping or withering occurs conspicuously in parts of plants which have been cut off in air. Thus, if we cut through the stem of a Sunflower (*Helianthus annuus*) or of the Birthwort (*Aristolochia Sipho*) and place it in water in such a manner that the cut surface and the water are in contact while the leaves are in the air, and then expose it to the daylight, we soon find that the water sucked up by the cut surface is not a sufficient quantity to compensate for the loss of watery vapour taking place by evaporation from the leaves, and the plant therefore, after a short time, droops and withers ;—cut flowers also soon become withered, shrivelled and flaccid through loss of water when exposed. This experiment shows us that the younger terminal leaf-bearing portions of the stems of plants which have large leaves, and consequently a large surface for evaporation, when they are cut off *in air*, partially lose the power of conducting water. The withered shoots of flowers, however, may be revived in a short time by forcing in water under pressure.

For this purpose, a U shaped bent glass tube is taken and filled with water, the stalk of the withered shoot is then passed through a perforated stopper of caoutchouc, and this is then fixed on to one end of the U tube, in such a manner as to be perfectly air-tight. Mercury is then poured in at the opposite

end until it stands in the open limb at a rather higher level than in the closed limb—viz., by eight to ten centimetres. A pressure is consequently set up and water is forced into the drooping shoot, which gradually revives and becomes turgid again, a series of spasmodic jerks occurring as the plant gradually becomes erect. The Indian Cress (*Tropæolum majus*) is a very good plant to perform an experiment of this kind on. It is noteworthy that the shoot remains turgid after the pressure has become reduced to zero by the mercury in the two sides of the tube coming to the same level, and even when the mercury is raised up by the suction of the shoot in the same arm of the tube to which the shoot is attached, so that a force is now acting upon the section of the shoot in an exactly opposite direction to that in which it previously acted. This shows that the forcing in of water is necessary only at first; afterwards the revived shoot has sufficient power of suction even to raise a column of mercury to a height of several centimetres, and thus to replace the loss occasioned by transpiration from the leaves. Hugo De Vries found that if rapidly-growing shoots of plants with large leaves are cut off at the lower part, which has become completely lignified, and are placed with the cut surface in water, they remain for some time perfectly fresh. If, however, they are cut through at the younger parts of their stem and placed in water, they soon begin to wither, as we have seen. This withering takes place more rapidly and more thoroughly in proportion as the part where the cut is made is young and not lignified. We can easily prevent this withering, however, by making the section under water, and taking care that the cut surface does not come into contact with the air. By these precautions, the disturbing influences are reduced to a minimum, and the conduction of water through the stem suffers no interruption. For if we compare the length of time during which a stem cut in water remains fresh, with that during which a similar stem cut in air does the same, we will find that the former will be much the greater. Or if we take care while we are making the cut in air, that the leaves and upper parts of the shoot lose only a very small quantity of

water by transpiration, withering will not begin till a later period, and will increase but slowly after the cut surface is placed in water, and the leaves again can transpire.

The cause of withering in all these experiments is an interruption in the power of conducting water from below, and this is due not only to the conduction of water ceasing for a short time, but also—and this is the more important element of the two—by a change taking place, which consists in the loss of water above the cut surface when the section is made in air, for section in air disturbs the relation existing between the water and the solid micellæ in the walls of the wood-cells, and hence exerts a distinctly injurious influence on the conducting power for water of the wood-cells in the stem, and diminishes it, because under the altered conditions water can no longer pass in the cell-walls with the same ease that it previously did. The loss of water cannot be restored simply by placing the cut surface once more in contact with water: for, when so placed, it takes it up but very slowly. That it diminishes the conducting power for water, we can easily show. If we cut off the stem of a Sunflower (*Helianthus annuus*) in the air and place it in water and allow it to remain for some time so that it begins to wither, and if we then carefully remove several of the lowest and largest leaves from the stem, we shall find that the growing apex and the leaves which are left will, after some time, begin to revive, even without any further cutting of the stem, which, as we shall presently see, restores conductivity. So that we see that the amount of water which is required to supply the transpiration of a large number of leaves cannot be conducted through the stem after it has been cut off in air, while the amount which is required to supply the transpiration of a few leaves, can; or, in other words, the cause of this is a diminution of conducting power for water, if the cut surface does not remain too long in contact with air, because a short exposure to the air increases the diminution to a much greater degree. This change occurs only in a short piece of the stem *above* the cut surface, and it is evidently due to the loss of water from the cells, caused by the suction of the higher parts

in obedience to transpiration, not being compensated by absorption from below ; and also to the fact that when we put the plant in water the cell-walls of the injured cells swell up and become mucilaginous, and they soon cover over the cut surface mechanically with a pellicle of abundant gummy matter ; this rapidly becomes filled with Bacteria, and in this way shuts off the interior of the cut stem from any contact with the surrounding water. Every circumstance which tends to increase this loss of water tends also to increase the loss of conducting power, and causes the shoot which is placed in water to wither more rapidly and more completely. We must, therefore, assume that the conducting power of the cells depends on the quantity of water which their cell-walls contain. That this assumption is a very probable one, we can show by forcing in water from below, under pressure, in the manner before detailed ;—*i. e.*, if we artificially increase the amount of water in the cells of this piece, we can also increase its conducting power. If the withered shoot or flower be placed in water of from 35 to 40°C. it will soon revive, and if then placed in water of 20°C. it will either remain fresh for days, as *e.g.*, in the Elder, or at least wither more slowly, as *e. g.* in the Artichoke.

If we are placing in water for purposes of experiment, the ends of shoots which have begun to wither after being cut off, it is only necessary to remove a second portion from the stem by means of a new cut made a sufficiently long distance above the original point of section, but this time under water, and the shoot revives. This applies also to cut flowers, which, under these conditions, remain much longer fresh than they would otherwise do. As regards the length of the portion necessary to be removed, it has been found that in the Elder (*Sambucus nigra*) to remove a portion six centimetres long in a herbaceous shoot of twenty centimetres was amply sufficient. In this last case of section under water, the water is immediately conveyed upwards, and the cells above the point of section recover their turgidity, so that then there is no loss of conducting power.

We have still to consider certain other phenomena.

It is well-known that if we prune a Vine in spring, before

the leaves are developed, what is called *bleeding* by gardeners occurs, that is to say, that water will gradually and slowly ooze out from the cut surfaces ; and closer investigation has shown that this water exudes from the openings of the large vessels. This may also be seen by cutting through several trees, as a Maple or a Birch, when a flow of water of considerable strength will take place, many pints of fluid being poured out from the cut surface for some time. It may also be seen in all woody shrubs growing vigorously and provided with a well-developed root system. If we cut through the stem of a Sunflower or of a Tobacco plant, a few centimetres above the ground, and prevent the evaporation which would take place from the cut surface, an outflow of fluid will begin after a time, which may continue for several days.

The boring or tapping of Maples for Sugar by means of holes is effected in the spring-time, for the longer stagnation in the cavities of the wood during winter gives the water the power of absorbing sugar out of the closed living cells of the wood, and out of the parenchyma surrounding them ; a result which cannot be expected, or only in a lesser degree, in the case of the rapid flow from the smaller root-stalks of quickly growing plants.

The presence of fluid in the vessels in the spring cannot possibly be due to the leaves, because they are either not unfolded at all, or, if they are, they are very small indeed, and, hence it must be due to some force exerted by the roots themselves. This force, known as the *root pressure*, is occasioned thus : the water is absorbed from the soil by the roots, and forced by means of the hydrostatic pressure set up in the parenchyma cells into the cavities of the vessels of the roots by a process of filtration, thence it is forced from the roots into the stem, so that when the latter is cut it is poured out. The amount of pressure exerted by this force of outflow is very considerable and easily perceived, and the amount of fluid given out very large ; it may be measured by attaching a glass tube containing mercury to the cut surface, when we find that the pressure is able to raise up the column of mercury for a con-

siderable height, which is equivalent to the pressure sufficient to support the weight of at least an atmosphere if not more, so that it is no hypothetical force we have to deal with. The limit of distance to which the mercury column is raised is, however, soon arrived at, and a condition of equilibrium between the downward pressure of the mercury and the upward pressure of the force is attained. No other force is present to occasion this root pressure than those of absorption and filtration under pressure, and hence this rise of liquid to a very considerable height is the expression of the absorbent activity of the parenchyma cells of the roots measured in millimetres of mercury; for the greater the facility with which they absorb moisture in the form of water, the greater is the filtration into the vessels, and consequently the greater is the flow of fluid in the case of cutting off a stem near the ground. When we put on the mercury manometer we oppose a substance—viz., mercury, to the filtration of the water into the vessels, yet, nevertheless, the active power is so great as to overcome the ordinary resistance, and also to lift the mercury column as well. In proportion, then, as the osmotic power of the parenchyma cells is greater, so will the root pressure be greater. This movement of water effected by the root pressure is particularly conspicuous in the early spring, when the leaves are just opening, and generally at the period of most vigorous growth. When the leaves are once developed and expanded, and transpiration has begun, the root pressure gradually diminishes, the accumulated water being evaporated until, when the plant transpires most, this root pressure is entirely absent; for, if we make a section in summer, no escape or flow of liquid can be obtained from the cut surface of the stem, though the absorptive activity of the roots is still going on, and the amount of fluid passing is very much greater than it was in the springtime, because the plant is continually losing water at its leaves, which are transpiring. As fast, however, as the liquid is absorbed by the root-hairs and passes thence by osmosis and filtration into the vessel-walls of the wood, it is no longer forced into the cavities of the vessels to collect there and be

easily seen when a section is cut, but it is carried upwards at once in the walls of the vessels to the leaves, to compensate there for the loss of liquid due to transpiration. On the contrary, if we pour water on the cut surface, it will be rapidly absorbed; for the vessels, as we have seen, contain no water, but only air at a negative pressure.

We see, then, that there are two kinds of pressure manifested by the roots: First, the endosmotic activity of the cells of the root, absorbing fluid from the exterior and passing it through their cell-walls and protoplasm, thence forcing it under pressure into the lignified walls of the vessels, whence it is conducted at once to the leaves in obedience to the demand created in them by transpiration. This pressure is always constant, and we cannot measure it. Secondly, the activity obtained by the presence of a condition of turgidity in the cells of the root, for taking up fluids to a greater extent than they can contain, and, consequently, for exercising a hydrostatic pressure, occasioning a process of rapid filtration into the cavities of the vessels: this is the externally evident *root pressure* of which I have been speaking, and its amount can be measured. The latter, as I stated, never coexists with transpiration. When we have root pressure evident there is either no transpiration, or its amount is exceedingly small, and in consequence of this the liquid has time to collect in the cavities of the vessels; but when transpiration has once begun, it is impossible to detect any evident root pressure, for the cells of the root never become turgid to the excessive degree required to force liquid through the walls of the vessels into their cavities, but remain tolerably flaccid; and, as we have seen, the evident root pressure depends on the turgid condition of the cells. When transpiration is going on we never have any water in the vessels: hence, when the leaves are actively transpiring there is no evident root pressure, and consequently, as we saw, the fluid transpired could not be supplied to the leaves from the root pressure, as was at one time supposed.

In the experiment of measuring the amount of the root pressure by means of the height of the column of mercury

which it can support, if the apparatus is left for some time it will be found that the level of the mercury will not be constant, but will oscillate slightly above and below the level at first attained, but will not deviate much from it on either side. These variations, it will be found, take place in a definite sequence, the entire round of which is accomplished every twenty-four hours, and to these variations in the root pressure the term *Daily Periodicity* has been applied. At first sight, this daily periodicity would seem to be due to external changes, *i.e.*, changes in the temperature of the soil and the air, produced by the alternations of day and night, affecting the root. There are reasons for believing that it is not due to this source, however, since we find a slow rise of the root pressure at the same time that we get a decline of temperature; and, further, the temperature of the soil never varies to such a degree in twenty-four hours as is required to produce these oscillations. Hence we may conclude that the temperature of the air and the soil has no important bearing on this daily periodicity. The influence of light appears the next likely agency to produce it; but it happens that if we put the plants in the dark these oscillations will go on just as well as they do in the light. It is not due, then, to variations in external conditions, but to variations in the absorbent condition of the root-cells. It is probable that these latter variations were induced in bygone times by variations in external conditions, and that these have become transmitted by heredity, so that the roots of the plant have become habituated to vary in their absorbent activity, and hence these variations can at the present time go on quite independently of the action of external conditions, *e.g.*, in the dark.

In herbaceous plants, the water forced up from the roots contains only mineral salts in solution taken up from the soil. In the Vine, Maple, and some trees, it usually holds in solution various organic substances, and particularly sugar, which it obtains from the stem.

In winter, the wood-cells and vessels contain water, together with larger or smaller bubbles of air; hence, if a hole be

bored into a tree in winter and the part be rapidly warmed, or if the temperature of the air be rising, the increase of temperature suddenly expands the air-bubbles mixed with the fluid, and causes the fluid to be driven out of the stem where it can find an opening. When the part is cooled again, the air contracts, and fluid is absorbed. This is sometimes confounded with the *bleeding* of plants, which we have seen is due to root pressure only. The exudation or movement of the liquid by increase of temperature can only occur in the winter and early spring, before the leaves unfold and transpiration begins, because it is only at that period that air and liquid exist together in the cavities of the vessels.

Rather a striking evidence of the existence of this root pressure, and a phenomenon well worthy of note, is the secretion or excretion, under certain circumstances, of actual drops of water, as *water*, by the leaves of certain plants. In the process of transpiration the water always passes off from the plant in the form of vapour, but in certain other cases we find that drops of water are exuded. This pouring out of water is due to the osmotic activity of certain structures which have received the name of *water glands*. As regards the position of these glands on the leaf, it seems to be the rule that they occur on the margin of the leaf. Exceptions to this statement are afforded by several species of Crassulas (*C. cordifolia*, *C. arborescens*, *and C. portulacea*), where they occur distributed over the surface of the leaf. In leaves with an entire margin they usually occur only at the apex, *i. e.*, the extremity of the main fibro-vascular bundles, as in the species of *Azalea*, *Myosotis*, *Arum*, *Caladium distillatorium*, *Musa*, *Richardia*, *Collocasia*, *Zea Mais*, and *Hordeum vulgare*. In leaves whose margins are cut or indented there may be a gland at the apex of each tooth, as in the Chinese Primrose (*Primula sinensis*), in *Fuchsia globosa*, and in the common Lady's Mantle (*Alchemilla vulgaris*); also, in *Bryophyllnm calycinum;* in the indentation between two teeth, as in *Crassula spathulata;* or even on the sides of the tooth, as in *Senecio petasitis*. In *Tropæolum majus* they occur only on the upper surface of the leaf near the margin.

In the species of Saxifraga (such as *S. crustata*) they appear to occur only on the upper side of the leaf, at the margins, in connection with the little depressions or pits between the lobes or crenations; in *Crassula lactea* and *C. coccinea*, on the upper and under margins, and in *Sedum Sieboldii*, only on the under side.

In *Saxifraga crustata*, which, according to the researches of W. Gardiner* has the most highly differentiated gland at present known, the adult structure of the gland is somewhat as follows :—The peripheral termination or ending of each of the fibro-vascular bundles which ramify through the mesophyll of the leaf presents the appearance of a swelling or dilatation at its extremity, which is roughly pear-shaped in outline, being broad towards the surface of the leaf, and tapering inwards towards the fibro-vascular bundle. Each of these dilatations is placed immediately under the bottom of one of the depressions which exist between each of the lobes of the leaf, and forms what is known as a *water-gland*. By far the larger portion of the tissue of the gland is made up of polygonal cells, slightly longer than broad, closely fitting one to the other without intercellular spaces. These cells are derived from the ground tissue at the apex of the termination of the fibro-vascular bundle. The cell-walls are thin, and the cells themselves are much smaller than those of the surrounding ground tissue. They contain no chlorophyll, and their protoplasm is very granular. The gland is invested by a sheath of cells containing chlorophyll corpuscles of one or at most two layers thick, which entirely surround it, with the exception of that portion of it which is covered at the surface of the leaf with epidermis. This sheath is continuous with the endodermis or bundle-sheath of the fibro-vascular bundles of the leaf, and by means of it the very definite group of cells which form the gland are exceedingly well marked off from the ordinary ground tissue which surrounds it. At the inner extremity of the

* See an admirable paper by him entitled "The Development of Water Glands in the leaf of Saxifraga Crustata," in the *Quarterly Journal of Microscopical Science*, New Series, No. LXXXIII, July, 1881.

gland, towards the fibro-vascular bundle, we find certain elongated fusiform or spindle-shaped cells, with reticulate thickenings on their walls, which cells are joined end to end, and eventually become continuous with the spiral vessels of the fibro-vascular bundle. These cells present a series of intermediate forms between gland cells with granular protoplasm and delicate reticulate thickenings on the one hand, and the spiral vessels of the bundle on the other, so that in the adult condition it is practically impossible to say exactly where the fibro-vascular bundle ends and the true gland tissue (derived, as we saw, from the the ground tissue) begins.

At the broad end of this water-gland, where it underlies the epidermis, we find one, two, or rarely three openings or apertures freely communicating with the external atmosphere through the epidermis: these are known as *water-pores* or *water stomata.* Each of these resembles an ordinary stoma, in the fact that it is bordered by two guard cells containing chlorophyll, which are, however, derived from the division of a single epidermal cell. These guard cells are larger than the ordinary guard cells of the stomata, and the two together have a rounded contour as compared with the elliptical shape of the pair of guard cells of a stoma proper. The actual pore, moreover, is relatively smaller than the opening of the stoma, and, unlike it, cannot be opened or closed according to the degree of turgidity of the cells of the leaf:—it is fixed, and always remains open. The time of development is also much earlier in the case of the water-pores, and their exact mode of development, as Gardiner has shown, is quite different from that of the stomata; they differ also in being confined to leaves only, whereas stomata, as we have seen, occur elsewhere as well. The position of these pores in *Saxifraga crustata* is on the margin of the upper side of the leaf, at the bottom of each of the depressions or pits which occur there. The mode of action of the whole apparatus is as follows:—Water occurs in the vessel-walls of the ultimate ending of the fibro-vascular bundle (which, however, is completely closed and blind); the cells of the gland in immediate connection with which it ends are, however, parenchymatous and capable of

absorbing water from it, which they do. These cells are also of the nature of secreting cells, so that the water which they absorb from the vessels of the bundle is poured by them into the water-pore. The vessels of the fibro-vascular bundle do not then open directly into the water-pore, but are separated from it by the parenchymatous cells which form the secreting gland, and the water is not poured into the pore directly from the vessels as if from a pipe. In the day-time, when the temperature is high and transpiration very vigorous, the secretion of drops of water does not take place, and even if water is secreted by the cells of the glands, it is evaporated as fast as it is secreted. But at night, when the temperature falls, causing decrease of transpiration, the walls of the vessels, and even the vessels themselves, become gorged with water, and every facility for secretion by the gland is offered. Under these conditions the cells of the gland become turgid, a pressure is set up, and drops of water exude through the water-pores. As we have seen, each water-pore is situated at the base of a depression or pit in the leaf margin. The production of these pits is due to cell division, though not to the growth of the cell, for this practically ceases in the tissue of the water-gland with the division of the epidermal cell into two to form the water-pore, while cell division still goes on in the rest of the leaf, ending only with formation of the stomata. The sides of these pits, especially the outer side, *i.e.*, the proximal side of the lobe to the stem,—are lined or fringed with small, knob-like, stiff hairs which are out-growths from the surface of the epidermal cells which forms the walls of the depressions. These cells, before the development of the pits, in the way above described, formed part of the margin of the leaf. The hairs are almost perfectly spherical, with very thick and highly refractive cell-walls. The water which exudes through the water-pores subsequently fills the pits, and as the hairs are most abundant on the outer side, when an excess of water is secreted and the pit overflows, this water tends to collect on this margin of the lobe. This water is not simply water alone but is charged with carbon dioxide gas, and holds in solution certain

mineral salts, more specially a quantity of calcic carbonate, or chalk. As the water evaporates and the carbon dioxide gas comes off, the chalk is precipitated, and that which is deposited in the neighbourhood of the pit tends to aggregate around the hairs, and becomes thus firmly held and prevented from falling into the pit and stopping up the open water-pore, thereby rendering it useless. In this manner the whole margin of the upper surface of the leaf becomes covered with little masses of chalk, indicating the openings through which the water is excreted. In spite of this special provision, however, the older glands frequently become inefficient on account of being choked, the pit becoming completely filled with the very large concretions of chalk formed, which appear to spread from the pit, covering the entire lobe and even extending over other parts of the leaf as well, in the form of a white incrustation. The whole of the phenomenon may be easily seen by placing a bell-jar over a vigorous plant. Since the air becomes saturated with aqueous vapour, transpiration is reduced, and large drops of water are secreted. On removing the jar the water rapidly evaporates, and a deposit of chalk is formed. Such is the mechanism of the water gland and pores in *Saxifraga crustata*, which is unique as regards the special provision for the deposition of the calcic carbonate, the distinct differentiation of the gland tissue, the well-marked sheath for the gland of endodermis, the extreme granularity of the protoplasm, and the activity of function. In the water glands of the Crassulas, *e g.*, *C. arborescens*, which are the next most highly developed, we have neither hairs, nor endodermis forming a gland sheath. The protoplasm is not nearly so granular, nor the activity so great. The diminution of gland tissue is often accompanied by an increase in fibro-vascular tissue, which appears to replace it. Thus, in the Crassulas, the reticulated cells at the base of the gland are much more numerous than they are in *Saxifraga*, and this seems to be a general tendency in the less highly differentiated glands. Between the water glands of *Saxifraga* and *Crassula* and those occurring in other plants there seems to be a wide hiatus. The well-differentiated gland and con-

spicuous difference between its cells and those of the adjacent parenchyma no longer occur; in fact the gland cells and the parenchyma appear to merge into each other. In *Alchemilla* the spiral cells terminating the bundle are simply continued to the surface of the leaf, and there is no proper gland tissue at all. But the water-pore long preserves its individuality, although in many cases it seems probable that its function is taken on by an ordinary stoma of which it is, even in its most differentiated form, but a modification. The number of water-pores in relation with each gland varies very much; there may be one or a group, thus—

In *Saxifraga crustata*, 1—2—3.
Bryophyllum calycinum, 5—6.
Crassula coccinea, 1—3.
Crassula spathulata, 15—20.
In Primula sinensis, 1—2.
Crassula lactea, 15—18.
Hordeum vulgare, 1—2.

In *Primula sinensis* the water-pores lie flush with the leaf surface. If we cut off a leaf and place it in water, the secretion of fluid in the form of drops of water will cease. If we take a whole plant of *Alchemilla vulgaris* and plant it in a pot, when the amount of transpiration from the leaves is very great, and consequently there is no evident root pressure, the excretion of drops of water by the leaves will cease; but if we place the plant under circumstances by which the amount of transpiration is diminished and the evident root pressure increased, we get drops of water secreted. These last-named conditions actually take place in nature, as we may see by considering what occurs in a small specimen of this plant through the space of a day and a night. At night transpiration is almost absent or very much diminished, while the root absorption is very active; hence the water accumulates and fills the vessels, thus giving rise to a root pressure which is so considerable that it fills all the vessels of this low-growing plant with water, and hence if we examine the plant in the morning before the sun has got to it we shall see large and numerous drops of water fringing the edge of the leaves, which are secreted or forced out by the water glands, and have

exuded out through the pores, of which there are in this case a considerable number to each gland, so that the amount of water poured out in this way by a plant may be considerable. During the day this process will cease, because the amount of transpiration is so great that it soon empties the vessels, and keeps them in that condition. That these drops are not drops of dew, as might be at first supposed, may be proved by placing a bell-jar cover over the plant, when we will find that the process still goes on, and consequently the water must be poured out from some part of the leaves themselves. This secretion of water depends on the evident root pressure, since it only takes place when we have fluid in the vessels, and will not take place when the leaf is cut off from the plant unless we replace the root pressure by forcing in water under the pressure of a column of mercury. According to Dr. S. H. Vines, and Dr. Moll, of Amsterdam, possibly some definite correlation exists between the presence of excretory organs such as water-pores, and the existence of evident root pressure in a plant. Hofmeister (Flora, 1862) could detect no root pressure in Conifers, where the vessels are few, the only ones being those first formed, which soon die; and Moll has failed to discover any excretory organs in their leaves.

In by far the larger number of plants, the activity and life of the water gland and structures analogous to it appear to be co-existent with that of the leaf as a whole. In certain cases, however—*e.g.*, species of *Musa*, *Richardia*, and the grasses, in which the gland is borne at the apex of the leaf—the apex soon withers, and the gland becomes destroyed. Thus, in very young barley plants (*Hordeum vulgare*), large drops of water may be seen hanging on the apex of each leaf, even though the temperature of the surrounding air be as high as 74° Fahr. As they grow older the secretion stops, and later each leaf apex withers up and dies. Another case of secretion or excretion of a very different nature is that of honey (which is a solution of sugar in water), by flowers. In this case the secretion or pouring out of water will take place for days just as well after we have cut off the flower from the stem and placed it in water

as before we did so, which shows that the secretion of these drops is perfectly independent of the rest of the plant and of the root pressure, and depends on the local activity of particular living cells. These cells form what are called *nectaries*, which are well seen in the Crown Imperial (*Fritillaria imperialis*), where they form large circular areas at the base of the perianth leaves. They have no special pores, and generally lie more or less on the surface, exposed freely to the action of the air, in a sort of depression of the epidermis, which, however, does not cover them; thus a little cup is formed by cells, which take up great quantities of water by the osmotic activity of substances in their cell-sap from the end of the fibro-vascular bundle over which their inner surface is always placed in direct contact, and which breaks up beneath them in a radiating manner. The activity of these cells is so great that more water is taken up than the cells can contain; they thus become turgid and a pressure is set up in them, in consequence of which water is forced out from them by filtration through the cell-walls, on to the exterior at the surface of least resistance, in order to prevent rupture taking place. In this case the cells appear to be able of themselves to set up a pressure in the absence of the root pressure which they were unable to do in the case of the water gland.

The causes of the ascending current of water are, then :—

I.—Internal causes, dependent on the plant itself:

A. The endosmotic *constant* activity of the root-cells, producing a suction on the soil.

B. Capillarity, which has a twofold action: 1. Its action in raising a column of water. This will, of course, have but little influence comparatively, except when water and air occur together in the vessels, or in the cases of root pressure in spring 2. Its action in maintaining a column of water when already raised.

C. Diffusion in its widest sense.

D. Imbibition.

II.—External causes:—

A. Transpiration, the *vis a fronté* giving the upward pull at the leaves, and causing a demand for the water absorbed by the roots to supply the loss which it occasions.

B. Variations of temperature which, by causing expansions and contractions of the air within the vessels affect the relative distances between the micellæ composing their walls, and thus produce local expansions and contractions, followed by currents of water.

C. The action of the wind, which causes the swaying of the branches and leaves. It is well known that if you bend a tube, such as a vessel, the calibre or size of the bent part is smaller than when the tube was straight, and therefore a bent tube will hold less than a straight tube; but not only does bending affect the calibre, it affects also the solid substance, by diminishing the distance between the component micellæ at particular points, and increasing them at others, for while one part is contracted another part is expanded. The result is that water is forced out where the distances are diminished, and since it cannot be forced downwards against all the forces acting concurrently which tend to bring it upwards, it passes upwards, for in this direction it has only its own weight to oppose it. The effect of the bending is thus to produce a local tension, and when this is removed there will be an upward current to supply the space which is left empty. In addition to this, in the parts where the distance between the micellæ has increased, more water is needed, and so there is an upward current to those parts also. So, then, every alternate bending, first to one side and then to another, produces a corresponding upward movement of the water, and the branches act as so many pumps, so to speak, doing their work slowly but surely, not by their cavities

but by the bounding walls of those cavities. The action of wind swaying the leaves causes an increased amount of transpiration to take place, and in this way affects the upward current.

Thus far we have dealt with the course and movement of the ascending current of water through the plant, maintained, as we have have seen, in obedience to the pull given by transpiration, the fluid being supplied by the absorptive power of the parenchyma cells of the root.

Now we have to speak shortly of what was formerly known as the "*descending current of the sap*," or "*the elaborated sap*." It was believed, and is still believed by many, that the ascending current of water, after being deprived in the leaves of a large portion of its water by evaporation and transpiration, descends again, taking a definite course after having received a new element into its composition, which substance is of the highest importance in the growth of the plant—viz., Carbon. This Carbon is obtained from the small quantity of the carbon dioxide gas which is present in the air, and which is taken up principally, as appears from the recent experiments of Boussingault, of which mention has been already made, through the cuticularised cell-walls of the epidermal cells covering the upper surface of the leaf, and not by means of the intercellular passages of the lower surface, and the stomata which communicate with them, as was formerly believed to be the case.

The green colouring matter, chlorophyll, so almost universally distributed in the vegetable kingdom, is present in the cells of the leaf parenchyma ; and under the presence of it, of an adequate supply of air containing the carbon dioxide, of bright sunlight, and of certain appropriate salts, more particularly salts of potassium, the plant is able to separate the carbon from the carbon dioxide, and to combine it with oxygen and hydrogen in the proportions in which the latter occur in water, and thus form the carbo-hydrate well-known as starch. The formation of the starch takes place only in connection with the living protoplasm of the cell, and the part of it specially set apart

for this function is the protoplasm which forms as it were a matrix in which the green colouring matter lies. For chlorophyll does not usually occur, staining the whole protoplasm of the cell after the fashion of a dye; but when the cell is examined by the microscope, under a power of a quarter of an inch objective, it is seen that the green colouring matter occurs in grains or granules of a rounded or angular form; and on treating these grains, granules, or corpuscles, with reagents such as alcohol and ether, it has been found possible to remove the colouring matter and leave the isolated grains or granules unstained. These isolated grains are nothing but living protoplasm, and it is in them that the first formation of starch from carbon and the elements of water takes place under the action of light.

If we place a plant in the light, we find that minute starch grains appear in these chlorophyll corpuscles of the leaves; if we then place it in darkness, we no longer find starch grains present in this position: the starch grains, then, which were formed in the light have been conveyed away in the dark. In what way is this starch conveyed away from the leaves and transmitted to the various parts of the plant? The cells of the leaves are completely closed, and starch cannot be conveyed away bodily from one part of the plant to another. Starch is also practically insoluble in water; hence, it must have been converted into some soluble substance, and one, moreover, which will pass by diffusion through the cell-wall. In the bodies of animals processes of conversion of this kind are always going on—*e. g.*, in the stomach, starch is converted into sugar under the action of certain bodies called *ferments*, and analogy leads us to believe that the same is the case in plants: that is to say, starch is converted into sugar, and into the particular form of glucose which is a substance soluble in water by the action of unorganized ferments; and then this sugar formed by the process of fermentation is removed from the leaves and carried away in solution to the other parts of the plant. These ferments are not only supposed to exist in plants, they have actually been discovered to do so in the cells of buds and leaves.

They are very active in germinating seeds, *e.g.*, in the process of malting barley. The ferment present in malt was first discovered and was called *diastase*, and hence all unorganized ferments which convert starch into sugar are called *diastatic*. But how does the sugar in solution pass through the protoplasm of the cells where it is transformed? for this offers a considerable resistance to the passage of substances through it. In the case of the beet-root, quoted in an early part of this paper, we saw that the cane sugar present in the cell-sap did not pass through the protoplasm and escape from the cells into the surrounding water in which the section was immersed, even when the cells were allowed to remain there for some considerable time. To this question it is, unfortunately, at present impossible to give a definite answer. Possibly the sugar at once undergoes a change into a substance which will pass by diffusion through the protoplasm more readily than it can itself do—*i.e.*, into some form of vegetable acid; or perhaps the sugar exists under these conditions of formation in a form different from, and more diffusible than, that in which it is met with after it has lain for a long period in the stores or reservoirs of the plant. There is no doubt whatever that it does pass in some form or other from the leaves to the other parts of the plant. If we assume either that it is directly converted into a very diffusible form of sugar, or indirectly into some diffusible substance, such as a vegetable acid, we have the key to the whole distribution of the sugar solution in the plant. Now it is the movement of this sugar solution which has been long known as *the descending current of the elaborated sap*. It was formerly said that its course was a downward one, through that portion of the growing wood in ordinary forest trees (Dicotyledons) which we know as the cambium; a zone of ordinary parenchyma cells capable of division, and from which the annual additions take place to the exterior of the wood proper which lies internally to it, and to the interior of what is known as the inner or bast layer of the bark, which lies externally to it; and also that it passed through certain vessels in this bast layer as well.

In reality the distribution of this sugar solution does not take place in any definite and determined direction, but can take place through the parenchyma cells of the plant in any direction whatever, upwards as well as downwards, by simple diffusion to those parts where it is required, *i. e.*, to those parts where growth is going on, and where there is a deficiency of sugar in consequence of a consumption of sugar material, and hence where there is a demand being set up for it. Thus, if we imagine a cell dividing and getting poor in sugar, in a plant in which, to begin with, all the cells were in *equilibrium*, that is to say, possessed of an equal supply of sugar or starch, immediately a demand is created from cell to cell throughout the whole plant for sugar solution, which passes by diffusion towards that point in all directions until equilibrium is again established. The distribution of this sugar solution in the plant depends, then, on the processes going on within the plant, which are using the sugar up in various ways. Consequently, the course of this sugar solution is very different at different seasons, since growth varies at different times. In spring we have active growth of the leaves, and growth of the wood in the stem and in the root, both in length and thickness. As the leaves form this sugar solution it is clear that when they are in the process of development they cannot form it for their own growth. The growth of the leaves takes place by means of the use of the reserve food material, such as aleurone and starch; hence in spring the current of sugar solution is not from the leaves to somewhere else, but from the reservoir, wherever it may be, upwards towards the growing organs—*e. g.*, leaves, flowers, &c., where it is being consumed to supply the material for the growing cells, and promote the development of those organs. When the leaves are formed, and active growth goes on in the stem, roots, and flowers, the direction of the current of the sugar solution is then, as I have stated, from the leaves to every part where growth is taking place; hence in summer its course is an indeterminate one. In the autumn we have less active growth, and the plant is then producing seed or laying up stores of starch and other substances for the supply of the next spring, so the

current of sugar solution will then be carried from the leaves to the seeds, or downwards to the base of the stem to some depository or reservoir, (root, rhizome, tuber, or bulb), because it is being there deposited bodily as starch (sometimes, however, it continues to exist in the form of sugar—*e.g.*, in the onion), and stored up either for use by the plant in the succeeding year, or for the development of the embryo, for in both of these cases there will be a demand for it which must be supplied. Starch, then, travels down from the leaves in a soluble form, through the parenchymatous cells to the cells of the tubers and other subterranean reservoirs, which are unable to form it for themselves, since they possess no chlorophyll, but only store it up by re-depositing it in the bodily form of starch in consequence of deriving a supply of sugar solution from the leaves. The parenchyma cells of the plant, in which the sugar solution passes, have always a very acid reaction to test paper; and it may be, as I have said, that the sugar is temporarily in the form of an acid, to enable it to be more easily transferred from one part of the plant to another. The transference of carbohydrate material does not, moreover, take place in one single stage only—that is, by starch being converted into sugar at the leaves, and this again re-converted into starch at the reservoirs; but it is interrupted or halts at certain periods on the way before it reaches its final destination, and the sugar solution is thrown down here and there, in the insoluble form of starch, in cells which are not reservoirs for starch: this latter at a subsequent period is re-dissolved.

The change of starch from the soluble form of glucose to the insoluble form in the reservoirs does not take place promiscuously in all the protoplasm of the cells of the tubers, &c., as was at one time believed to be the case, but is confined to certain special portions of it, forming bodies known as *starch-forming* corpuscles. These have been most specially studied by A. F. W. Schimper, in the tubers of the potato, and also in various roots and rhizomes* If a piece of a potato tuber be exposed to

* "Researches upon the Development of Starch Grains," *Botanische Zeitung*, 1880, No. 52, translated in *Quart. Jour. Micros. Sci.*, New Series, lxxxii., April, 1881.

the light it turns green, and it is the starch-forming corpuscles which, though normally colourless, can and do become green under the action of the light. The correspondence between the chlorophyll corpuscles and these colourless corpuscles which exist in the internal reservoirs is then a very close one.

Each starch-forming corpuscle consists of a small portion of differentiated protoplasm, which varies in shape according to the plant examined; in many plants they are rod-shaped in form;—in the potato tuber, however, they are circular. They are especially abundant in the immediate neighbourhood of the nuclei of the cells; thus if the cells of a section of a tuber of the potato immersed in alcohol be examined, a number of those protoplasmic circular bodies will usually be found surrounding each nucleus. The starch grain in its earliest stage of development projects from each of these as a little hump or protuberance on one side of the corpuscle, which, when treated with iodine, turns a blue colour, showing that it is starch that is present. As the starch grain grows rapidly, in later days we find that it has increased enormously in size, while the corpuscle is then almost undistinguishable and is soon lost sight of. The starch grain of itself cannot grow, it is only able to do this in consequence of certain processes of change taking place in these corpuscles. Directly the starch grain becomes free from its starch-forming corpuscle all further growth ceases, for it can only grow so long as its connection with the starch-forming corpuscle remains unbroken.

Since the sugar solution is thus deposited, a demand for a further supply will be created, which has to be supplied. But in the spring, when growth is active, the starch in the subterranean reservoirs—roots, tubers, rhizomes, &c.—becomes at once reconverted by the action of a ferment into solution of sugar, to fit it for being more easily carried, and in this form it passes upwards by diffusion through the parenchyma cells towards the leaves. The movement of this solution of sugar is now known as the "*slow movement of fluids in plants.*"

That the starch is reconverted into sugar is well known. Starch grains have been observed in various stages of disap-

pearance, being gradually eaten away and frayed out from the surface by something present in the cells, and this has been especially seen in observations made on seeds. The starch grains do not dissolve entirely at once, but gradually dissolve from the outside, in somewhat the same manner as sugar does in hot water, its solution being due to the action of a diastatic ferment.

We see, then, that the direction of the slow movement of fluid is determined by local circumstances, and the reason it does descend to the root and not ascend to the inflorescence is simply in relation to the demand for sugar there. Wherever the simple unaltered parenchyma tissue remains in the plant, with unaltered cell-walls through which this diffusion may prevail, there we may have this sugar solution passing; consequently we find it in certain strands of these cells which run at intervals from the pith to the inner layer of the bark (bast layer), and which are known as the "medullary rays;" its usual course is through the growing cells of the cambium zone.

The slow movement of fluid is, then, of an essentially different nature from the rapid movement due to transpiration and the other causes which we noticed. I do not think that this movement of the sugar solution is in any way a return current downwards of the remainder of the fluid which, with mineral salts in solution, being deprived of its nutrient substances as it goes on its way, at length finds its way to the leaves, and there deposits in the leaf-cells the salts which it contains, which are of no further use in the plant's nutrition, the water passing off in the form of watery vapour through the stomata; but it is a new current, set up, in obedience to the laws of diffusion, towards the points where there is a demand, and traversing the parenchymatous tissues where such laws hold complete sway.

In addition to the sugar solution we have certain other bodies —viz., the crystalline nitrogenous bodies, such as asparagin, leucin, and tyrosin, which are formed as the products of a long series of transformation changes on the proteids. These are readily diffusible, and can pass with ease, in solution in water, from cell to cell through the cell-walls of the parenchymatous

tissues of the plant, by diffusion; their distribution, like that of the sugar solution, being regulated by the principle of demand and supply.

If we cut through and remove a ring of bark for the breadth of one inch, down to the very surface of the wood, taking care, also, to remove the cambium zone, from the stem of a willow, for instance, since this forms a good subject for operating upon, we shall find that the part of the stem below the ring is materially injured, though the upper part is not so. If we leave it for some time the upper part thickens, produces rootlets and buds, and also branches vigorously; while the part below the ring does none of these. The upper part remains in connection with the leaves; but the removal of the ring of bark has interrupted the passage of the substances formed in the leaves, both non-nitrogenous and, as we shall see presently, nitrogenous also, which the lower portion requires for its growth; so that this part is deprived of its nourishment, and, in consequence, it remains dwarfed and arrested, while the rudiments of buds which were previously present upon it remain undeveloped. By this experiment we have shown that the nutritive substances from the leaves pass by the elements contained in the outer layers of the stem, external to the wood, which we have removed. Ringing fruit trees in this way causes a swelling of the tissues, and a temporary increase in the production of fruit above the wound, since there is less growing surface to be supplied. According to Sachs, if we cut a transverse section of a herbaceous stem, such as the cucumber, dry the cut surface and place neutral test paper, previously moistened with water, upon it, we find that certain parts of the test paper become red and certain others blue;—those parts which are colored red, indicating an acid fluid (containing sugar, oil, and vegetable acids formed from starch in various ways), correspond to the position of the parenchyma cells of the plant, viz., the cambium, the medullary rays, and the parenchyma of the bast layer; while those which are colored blue, and indicate an alkaline fluid (containing, according to him, substances of an albuminous or nitrogenous nature), correspond in position to the bast portion of the

bark, and more particularly to the elements in it known as the sieve tubes.

I have shown that almost the entire amount of the fluid absorbed by the roots is expelled in the form of watery vapour by the leaves in the process of transpiration, and that when this supply is either insufficient to meet the demand occasioned by transpiration, or is interfered with, the phenomenon of withering takes place. Also, that the descent is determined by local circumstances; that its course is regulated only by the physical laws of diffusion rendering it necessary that it should pass through the parenchyma tissues; and the interpretation to be placed upon the latter part of the observation which I have mentioned, alone remains to be noticed. The alkaline reaction is due to the presence of a proteid substance which is capable of being assimilated by the protoplasm.

It seems, then, that proteids, as such, and otherwise than in the form of nitrogenous crystalline bodies, are conveyed by the plant. These proteids are stated to be formed by the combination of starch with the body known as asparagin, since this latter body is only absent when active formation of starch is going on in the cells of the plant. If the plant be placed in the dark, we get formation of asparagin in the cells of the plant, but no formation of starch. Asparagin is regarded as formed by a very complex series of degradation changes from the original nitrogenous protoplasmic material of the plant, and in this way, in combination with starch, it is regarded as being rendered again capable of being used up and brought into the substance of the protoplasm once more. It is this body, then, that passes in the form of solution through the sieve-tubes, which consist of cells laid end to end, the transverse partition walls between which cells have become perforated by canals, so that the contents of long lengths of cells communicate with one another; and thus afford a means of conveyance for proteids, as such, from one part of the plant to another. They appear to pass mainly by diffusion through their walls to any point where fresh material of this kind is needed to sustain the life of the plant, in consequence of a consumption of them at that point, otherwise there is no current at all.

The plant seems to get on better if the sieve-tubes be left untouched in the experiments of ringing trees, than it does if they are removed along with the other elements included by the ring.

In some plants also, as the Euphorbias, the Poppies, and the section of the Compositæ represented by the Dandelion, we find certain vessels present in the bast, known as *laticiferous vessels*, containing a milky fluid, one of the constituents of which is proteid material which is thus transported in this channel from one part of the plant to another. These vessels seem to have some influence in distributing the substances formed in the leaves; their use for this purpose is, however, a secondary one, and they are not essential elements, since they are only present in a few plants.

Lastly, we have the *movement of water in the process of growth.*

The growth of the cells of plants is always connected with the absorption of water, and this not only as regards the size of the cell vacuole; for the growth of the cell-wall, &c., is also accompanied by the intercalation of particles of water between the solid micellae.

Water must, therefore, be conducted to the growing cells and tissues, and when the organs which absorb the water lie at a distance from those which require it from their growth, the movement of liquid is necessarily considerable.

Water is also required by the organs of assimilation, since it gives the hydrogen required for organic compounds.

The reservoirs of nutrient matter, in which substances such as starch are for a time accumulated, also require water to enable them to dissolve these substances, in order that they may be transported as formative material to the leaves and growing apices of roots and stems. All these movements of water, which are necessarily connected with nutrition and growth, proceed slowly, like growth itself. Their direction is from the nearer parts first, then from the more distant, and finally from the external medium. The water travels slowly by osmosis, from cell to cell, through the parenchyma, and as the equilibrium

between the individual cells is destroyed by the consumption of water in the growing cells, the water from the more distant portions of the tissue is absorbed to restore it. The growing cells contain dense protoplasm and need much water, the older parts contain less dense protoplasm and much cell-sap, and the still older parts only cell-sap.

In conclusion, I must thank you for the attention which you have given me while I have endeavoured to treat this intricate and difficult subject in as plain a manner as I could think of, and I trust that in some respects at least I have not left unfulfilled the task I had set myself, viz., to give some account of the mechanism whereby the movements of fluids in plants is determined. My thanks are also due to my friend W. Gardiner, B.A., for valuable information concerning his researches on water glands and water pores, without which this essay would have been necessarily incomplete.

[The paper was illustrated by diagrams and drawings of some of the various parts of plant structure noticed during its progress.]

15th February, 1881.

Mr. R. Young, Vice-President, in the Chair.

Mr. Robert Young, C.E., read a Paper entitled

REMARKS ON HOW IDEAS OF HEIGHT ARE FORMED.

The attention of the writer was drawn to the importance of this subject by a singular experience he had lately, when visiting the coast of Clare.

When a young man, with a strong relish for the wilder aspects of nature, he had the good fortune to be located for a considerable time in the vicinity of Ballycastle, and during his leisure had ample opportunities of examining and sketching the bold headlands and sea cliffs from Benmore on one side to Pleaskin on the other. Some years afterwards he had the opportunity of carefully studying the rest of the grand coast line of Antrim from Cushendun to Larne, and making drawings of the most picturesque points; so that these familiar Antrim cliffs became the standards to which he naturally referred any cliffs or precipices he met with in other places. Of late years, on several journeys both in England and Scotland, and in the Continent, he had been struck with the singular tameness of cliffs which he found exceeded those on our coast in height, but failed to impress the mind as forcibly. It was not, however, till lately that the full explanation of this curious phenomenon occurred to him.

In making a tour, last August, through Clare and Kerry, he had turned aside to visit the famed cliffs of Moher, about the

grandeur of which so much has been said; and their height being upwards of 600 feet, and springing sheer from the Atlantic waves, he naturally anticipated being impressed with a feeling of sublimity. The day was calm, and he was able to approach the extreme edge at one of the little outlooks considerately furnished by Mr. O'Brien, the owner of the place, and there to make a careful drawing of the range of cliffs extending towards Liscanor; but the feeling he experienced was that of disappointment and depression of spirits, instead of elevation. Instead of the sensation being equal to that experienced at the Fair Head, it seemed to be even less than one feels at the sight of Pleaskin, which does not reach 400 feet. What can this mean? The explanation would seem to be this:—

The Moher cliffs are composed of a vast mass of thin slate beds, slightly tilted up towards the sea, of a dull, sooty tint in general, and only relieved here and there by a little local colour from lichens. The slaty structure can only be *faintly* seen in the nearest cliff, at about 200 yards distance; and those beyond it show simply one uniform dark grey tint, and might be of sandstone or trap, for any external evidence to the contrary. In short, what is wanting is a modulus or scale to give the eye and mind a means of piling up the idea of height.

Standing in a similar position at Pleaskin, Co. Antrim, how different everything is found.

Beginning at the sea level are beds of tabular trap and amygdaloids, separated by thin veins of red ochre—above these, the stratum of red ochre, which forms such a striking feature in other parts of the headlands, and is upwards of 25 feet thick—above this rise the magnificent basaltic columns which are seen at a glance to be not a whit less in bulk than those which can be approached and handled at the Loom, or at the Giants' Organ, and which are known to be at least 50 feet in height. Resting on these pillars is a mass of basaltic rock, partly amorphous and partly prismatic, which the eye tells you is somewhat thicker than the range of columns; and above this stands a second tier of basaltic pillars even larger than the lower ones. The upper portion of the cliff is composed of several strata of

greenstone, separated by partings of lignite and red ochre, and in the aggregate is about twice the depth of one range of columns, or somewhere about 100 feet in thickness.

In addition to the scale of measurement afforded by the columns, it is obvious that the strongly-contrasted structure of the alternate beds of rock, and the variety and piquancy of effect arising from the bright tints of the ochre beds, which draw the eye, as did the rubricated lines in the old MSS., to important passages, all help to create the impression of size and importance of this magnificent headland.

It has often been remarked that visitors to the Causeway have been disappointed with what they have first seen at the Grand Causeway, but have expressed their admiration afterwards, when brought to Pleaskin and Benmore. Very likely this mainly arises from their carrying with them the idea of the size of the columns with which they had been brought in contact at starting, and which now serves them as a scale when they try to form a notion of the height of the huge sea-wall in which they again find these familiar forms rising in symmetrical ranges one above the other. In short, the effect of natural scenery must depend very much on how the eye has been disciplined previously by the examination of forms of the same or somewhat similar character.

The principle of aggregation, or multiplicity of parts, in helping to an estimate of vastness, as in the pictorial representation of mountain forms, has been well explained by Ruskin in "Modern Painters," and illustrated by his own exquisite drawing of "A Buttress of the Alps." In architecture, also, it is well recognised; and by acting on this knowledge, the designer of St. Paul's, in London, produced a building which, although much inferior in size, strikes the mind with a greater idea of sublimity than St. Peter's, at Rome, with all its lavish expenditure.

15*th February*, 1881.

Mr. R. Young, Vice-President, in the Chair.

Mr. Wm. Swanston read a Paper on

SOME OLD COINS FOUND RECENTLY BETWEEN TIDE-MARKS AT KILROOT NEAR CARRICKFERGUS.

The next communication was by Mr. William Swanston, who exhibited and gave an account of several old coins, both silver and copper, recently found between tide-marks a short distance to the north of Carrickfergus. The coins consisted of several silver of Charles II., base coinage of Philip and Mary, a few, apparently Scotch, of copper, and several local tokens, &c. Of the tokens, one was by "Anthony Hall, in Carrickfergus," two were of Belfast issue, but the names were undecipherable. Strange to say, there was also one Roman copper coin in fair preservation; also a seal-like article, with an inscription in early English letters, and very similar in character to an article in the Benn collection.

In connection with the above subject, a copy of M'Skimin's History of Carrickfergus, and the first edition of Benn's History of Belfast, in which many local tokens are figured, were handed round.

15th February 1881.

Mr. Robert Young, Vice-President in the Chair.

Mr. A. O'D. Taylor read a paper on

BELFAST INVESIGATORS FROM 1808 TO 1820 IN VARIOUS BRANCHES OF NATURAL HISTORY.

15th March, 1881.

The President, Professor Purser, in the Chair.

Professor E. A. Letts read a Paper on

RECENTLY-DISCOVERED ARTIFICIAL COLOURING MATTERS.

Professor Letts stated that the origin of the industry in artificial colours was the introduction of gas as an illuminating agent. About the year 1739, the Rev. Dr. Clayton, Dean of Kildare, obtained combustible gas by heating coal; but the inventor of practical gas-lighting was Murdoch, who, in 1792, lighted his workshops at Redruth, in Cornwall, by its means, and in 1802 established a gaswork at the Soho Foundry, near Birmingham, the property of the well-known firm of Boulton and Watt. Ten years later the invention was introduced into London, and gas-lighting soon became general.

Every one knows that gas is produced by heating coal, and that tar is obtained as a bye-product. Neither of these pre-exists in coal, but both are produced from it by extremely complex changes in the material of which the coal is composed. Now, tar, which may be defined as the liquid substances produced by heating coal, is a mixture of a great many very different bodies; over forty have been separated from it already, and no doubt others remain to be isolated. In spite of the immense wealth lying latent in coal-tar, it was at first regarded as a useless bye-product, and was sent down the sewers or burned. But now it

is so valuable that, were the electric light to supersede gas as an illuminating agent, it is probable that we should still have to prepare tar almost, if not quite, in as large quantities as at present. The lecturer then explained how the first aniline colour was discovered. Aniline was first obtained by Unverdorben, a German chemist, by distilling indigo, and derives its name from *anil*, the Portuguese for indigo. Later it was found to be present in coal-tar. For ten years it was regarded simply as a chemical curiosity, and was without practical application. In the year 1856, however, Mr. Perkin, whilst endeavouring to obtain quinine artificially, discovered that aniline, when treated with oxidising agents, yields a splendid mauve dye. Thus the first of the aniline colours was discovered by accident; and the lecturer pointed out how often it has occurred that investigations of a purely scientific kind have led to important practical results. This was the case with the discovery of chloroform, and also paraffin. The mauve dye attracted universal attention, and, as a consequence, the study of aniline and coal-tar products was pushed on with great vigour, with the result that a large and very profitable industry came into existence. The lecturer then explained that the quantity of aniline present in coal-tar is so minute that it would be very expensive if it could only be obtained directly from the tar. But, fortunately, it can easily be made from benzol, a hydrocarbon which is abundant in tar. This, when treated with aquafortis, gives nitro-benzol, a substance smelling like oil of almonds, and used, under the name of *oil of mirbane*, in perfumery. The nitro-benzol, when boiled with vinegar and iron, gives aniline. Rosaniline was discovered about the same time as the mauve dye, and is prepared from commercial aniline by heating it with arsenic acid. It is a splendid red-colouring matter of intense tinctorial power. Hofmann very carefully examined it, and found that it could not be prepared from pure aniline, but only from a mixture of aniline and a very similar substance found in commercial aniline called toluidine. Rosaniline is the starting point for a great number of very beautiful colouring matters. The first discovered of these were the *violets imperiales* and *bleu lumiere*, which

were made in France by heating aniline with rosaniline. Hofmann found that they were derivatives of rosaniline, resulting from the replacement of hydrogen by a compound called phenyl, and that the more the hydrogen was thus replaced, so much the bluer was the colour. In a masterly research Hofmann showed that other groups could be introduced into rosaniline instead of phenyl, and that very beautiful colouring matters resulted. The so-called Hofmann violets are of this description, the group introduced in place of the hydrogen being either methyl or ethyl. Two other colours are produced from rosaniline—one is the so-called gas green or iodine green, and is obtained by the same processes as the Hofmann violets. The other is a yellow dye called chrysaniline or phosphine, and is found in the residues of the rosaniline manufacture. Other dyes made from aniline have a brown colour, and a very fast black can also be prepared. The lecturer then showed experimentally how easily some of these dyes are prepared, and how simple an operation dyeing silk and wool with them is. In fact, fabrics made of the latter are at once dyed by simply immersing them in a solution of the colouring matter. He then said that the anthracene colours were of great importance, and explained how they were first made artificially. The Egyptians employed madder as a dye, for it has been found in the cloths in which mummies are wrapped. The colouring principle of madder was discovered by two Frenchmen, and was named *alizarine* by them. Two German chemists showed that alizarine is a derivative of anthracene, a hydrocarbon found in tar, and they then discovered a process for converting anthracene into alizarine. This process was improved by Mr. Perkin, and is now carried out on the large scale. In fact, very little madder is now cultivated, the artificial dye-stuff being employed instead. The lecturer showed what remarkable tinctorial properties alizarine possesses, and also dyed some cloths various colours by its means. He expressed his thanks to Messrs. Crum & Co., of Thornlie Bank, near Glasgow, for the beautiful specimens of dyed fabrics they had kindly given him. Dr. Letts then passed on to say a few words about Professor Baeyer's researches on

some curious substances called *phthaleines*, some of which are dye-stuffs. One of these, called *fluoresceine*, is a very curious body, which, when dissolved in hartshorn, shows a splendid green fluorescence. The lecturer concluded his sketch of artificial colours by mentioning that indigo had lately been obtained artificially by Professor Baeyer, and that attempts were being made in Germany to prepare it commercially. He believed that the culture of indigo will soon be a thing of the past.

12th April, 1881.

The Vice-President, Robert Young, Esq., C.E., in the Chair.

Mr. Joseph Wright, F.G.S., read a Paper,

NOTES ON THE FORAMINIFERA—GENUS LAGENA.

After briefly referring to the structure and classification of foraminifera, Mr. Wright went on to speak of their abundance almost everywhere over the bed of the ocean, the white oozy material frequently dredged from great depths being known as globigerina ooze, from the abundance of *Globigerina* found through it. He instanced in illustration of the abundance of foraminiferal life at some places, that in one ounce of mud gathered by Mr. John Pim off the fluke of an anchor at Vikholmen, Norway, and sent to him for microscopic examination, he found sixty-two different species of foraminifera, some of them represented by hundreds of individuals. He then spoke of *Lagena* as being the simplest form of the hyaline foraminifera, consisting of one chamber, and frequently covered with most varied and beautiful shell ornamentation. Many of the deep-sea forms have long projecting spines. These, he suggested, might be to assist them in maintaining an upright position in the soft ooze in which they are usually found. *Lagenæ* have attained their maximum development during recent times. They are of rare occurrence in the Mesozoic and Palæozoic periods, although other forms of foraminifera are abundant. Our leading British rhizopodists are of opinion that connecting links may be found

between nearly all the species of foraminifera. With regard to *Lagena*, he said all our British flat Entosolenian *Lagenæ* have their three-sided representatives in the Estuarine Clay at Limavady Junction, and he suggested these might be intermediate links between the flat and round *Lagena;* also that an Australian *Lagena* had been found not unlike *Lagena costata*, having a slit aperture, a character which had been considered characteristic of our flat Entosolenians. He also added that the bilocular *Lagenæ* occasionally met with might be the link between *Lagena* and *Nodosaria*. The paper was illustrated by diagrams.

12th April, 1881.

Mr. Robert Young, Vice-President, in the Chair.

Mr. A. O'D. Taylor read a Paper on

THE WILD BIRDS' PROTECTION ACT, 1880.

Mr. Taylor pointed out that there had been since 1869 three Acts passed on this subject. The first of these was "An Act for the Preservation of Sea Birds," passed in the 32nd and 33rd year of the present reign; the second, "An Act for the Protection of certain Wild Birds during the Breeding Season," passed in the 35th and 36th year; and the third, "An Act for the Preservation of Wild Fowl," passed in the 39th and 40th year. The last one—that now under consideration—was passed in the 43rd and 44th year of Victoria, 7th September, 1880, and came into force on the 1st March, 1881. Its title was "Wild Birds' Protection, 1880." The main object of all these Acts was undoubtedly a wise and kindly one—namely, to afford to all those birds whose habits are not in themselves injurious to the interests of man that immunity from molestation which all animals require while looking after their young. The salient features of the present Act are as follows:—First—The close time is from 1st March till 1st August inclusive. Second—If within that period any bird specified in an annexed schedule of 85 birds be killed by shooting or trapping, the penalty for each bird so shot or trapped, or attempted to be shot or trapped, or exposed for sale (after the 15th March) shall be a sum not exceeding 20s. Third—If the bird destroyed be an unscheduled one the offender shall, in the first instance, be reprimanded, and

for any offence thereafter the penalty shall not exceed 5s. for each bird. Fourth—Power is given to the principal Secretaries of State in Great Britain, and to the Lord Lieutenant in Ireland, to extend or vary the close time. Fifth—The Act extends to England, Wales, Scotland, and Ireland, but not to the Island of St. Kilda ; and a power of exempting any county or part of a county is procurable upon the application of justices in quarter sessions. A brisk controversy has sprung up as regards the dates fixed, and the chief contention has been about the month of March. Mr. Taylor gave extracts from various communications on this point from gentlemen in England and elsewhere, some few in favour of an earlier date than 1st March, but most in favour of a later date. Coast shooters seem in favour of the month of March being an open one ; inland gunners hold the contrary opinion. Mr. Taylor was in favour of the former view as regards the coast and estuaries, because in the month of March immense flocks of geese and duck are passing northwards to breed—birds which are really migratory, and which rarely breed in these latitudes, their nesting places being in Lapland, Arctic Siberia, and even away in the Arctic circle. It seems hard to professional shooters to debar them in March from the legitimate exercise of their profession as regards birds which do not breed in these islands. The 1st of April would be a fair date to meet such cases. There is, fortunately, an elasticity in the Act, through the power given of varying the close time, which might practically be so used as to meet the different requirements of different parts of the country. Mr. Taylor considered the amount of imposable fine, 20s., excessive, as scarcely any bird is worth more than 5s. for table. Except in some aggravated case, 5s. and costs seems ample. There have already been several convictions in London, Liverpool, and Hull under the new Act. Another point where a practical absurdity is not unlikely to arise was illustrated thus :—The justices of quarter sessions in one county may seek and obtain a modification of the close time, and the justices of the adjoining county may seek aud obtain a different modification. County Antrim may set the close time to end 15th July, and County Down may be

content to allow the 1st of August, as specified by the Act, to stand. On the 16th of July a gunner may then shoot with impunity a gull at one side of the River Lagan, which divides the two counties ; but if another gunner shoots the gull's mate at the other side of the river, he may be taken before a magistrate and fined 20s. There is a peculiarity in the last clause of section 3 of the new Act, which, in Mr. Taylor's judgment, greatly impairs the catholic character of the Act, and places under the control of private fancy or caprice the killing or capture of all birds not in the privileged schedule. In other words, this clause seems to place the owner or occupier of the land, or any one delegated by him, above both the letter and spirit of the Act. The words run thus :—"This section (namely, No. 3, specifying the penalties) shall not apply to the owner or occupier of any land, or to any person authorised by the owner or occupier of any land, killing or taking any wild bird on such land, not included in the schedule hereto annexed." Such a permission seems to contradict the very basis of the Act stated in the preamble, which says, "Whereas it is expedient to provide for the Protection of Wild Birds of the United Kingdom during the Breeding Season." How the expediency of the protection is in any way done away with by the honour of being done to death by a landlord or by some one delegated by him, Mr. Taylor failed to see. A curious legal point has already arisen in connection with the clause—namely, does this admitted privilege of capture and killing justify possession or exposure for sale? At Hull, on the 28th of March this year, this case was tried, and the magistrate, after a day's consideration, decided it did not justify exposure for sale. The want of provision for guarding eggs seems to be a serious defect in the present Act. It seems, strange to say, the law will take no cognisance of the germ which developes into the chick, but only comes into force when the chick emerges from the shell. The eggs, at least, of such birds as breed in colonies, and are, therefore, much more exposed, should be protected for some limited time of the breeding season. The ten or eleven weeks from the 15th of May till the 15th August would be sufficient to ensure the sea-birds at our

various breeding haunts round our coast being able to rear at least one brood in peace and comfort, provided their eggs were held sacred during that period. Plover, snipe, and some other birds which breed inland in colonies would need similar protection for their eggs. Mr. Taylor stated he was not at all in favour of over-legislation, and that he held a government might become too paternal; therefore he was not in favour of any legal punishment or fine being imposed on every thoughtless little boy who robbed a bird's nest. Strongly as he deprecated such cruelty, he thought that as regards the solitary nests of our ordinary small birds, home-teaching and the inculcation of thoughtfulness and kindness for the lower animals would be a sufficient safeguard against destroying most birds' eggs. Parents, teachers, and the admirable lessons inculcated in various ways by the Society for the Prevention of Cruelty to Animals, might safely be left to guide public sentiment and the habits of boys about taking birds' eggs from mere wantonness. As regards the schedule annexed to the Act, it is a defective one in the nomenclature, without entering on what reasons led to the rather puzzling selection of privileged birds. The local English names of several species were given—names which none but students of ornithology could recognise. Then, there seemed some extraordinary confusion in actually repeating the same bird under different names—for example, on the schedule the gannet is mentioned in one place and the solan goose in another; the two names are for the same bird. The curlew is mentioned in one part of the list, the whaup in another:—to these the same remark applies. The new Act, however, as a whole, being well meant and carefully devised, should have a fair trial, and, perhaps, hereafter, some of the improvements suggested might be added to it.

DONATIONS TO LIBRARY DURING SESSION 1880-1.

Adelaide.—Philosophical Society. Anniversary Address of the President, R. Tate, 1879.

Zoologica et Palæontologica Miscellanea. South Australia. R. Tate.

Natural History of the Country Around the Head of the Great Australian Bight. By R. Tate.
The Author.

Transactions and Proceedings and Report of the Royal Society of South Australia (late Adelaide Phil. Socy.) Vols. 1, 2, 3. *The Society.*

Belfast.—Birds, Fish, and Cetacea frequenting Belfast Lough. R. L. Patterson. *The Author.*

Proceedings of Belfast Naturalists' Field Club, 1879-80.
The Club.

Boston.—Proceedings of Boston Natural History Society. Vol. 20, Pts. 2 & 3, from November, 1878, to Jan., 1880. *The Society.*

Science Observations. 29, vol. 3, No. 5. 31, vol. 3, No. 7, 1880. *The Editor.*

Bologna.—Rendiconto delle Sessioni Dell Accademia Delli Scienze Dell' Instituto di Bologna, 1878-9, 1879-80.
The Society.

Brussels.—Bulletin de la Societe Royale de Botanique de Belgique. Tome dix-neuvieme, Fascicule, premiere et deuxieme. *The Society.*

Bulletin de la Societe Entomologique de Belgique. Series 3, No. 1. *The Society.*

BERLIN.—Verhandlungen der Gesellschaft fur Erdkunde zu Berlin. Band 8. No. 1, January, 1881; No. 2, February, 1882. *The Society.*

BRIGHTON.—Annual Report Brighton and Sussex Nat. Hist. Society. *The Society.*

BRESLAU.—Zeitschrift fur Entomologie, Breslau; Neue Folge Siebentes Heft. 1879. *The Society.*

CALCUTTA.—Geological Survey of India. Monograph on Fossil Corals, Alcyonaria of Sind. 28 plates. Ser. 14, vol. 1. 1880.

Geological Survey of India. Memoirs. Vol. 17, pts. 1 and 2; vol. 15, pt. 2.

Palaeontologica Indica. Series 10, pts. 4 and 5; 13, part 2.

Records. Vol. 12, part 4; and 13, pts. 1 and 2.
The Survey.

CARDIFF.—Naturalists' Society Report and Transactions. Vol. 11, 1879. *The Society.*

DANZIG.—Schriften der Naturforschenen Gesellschaft in Danzig. Book 4th, part 1880.

Danzig in Naturwissenscaftlicher und Medizinischer Beziehung. Danzig, 1880. *The Society.*

DUBLIN.—Royal Dublin Society Journal. No. 45, vol. 7, 1878.

Scientific Proceedings. Vol. 1 (N. 5), part 1, 1878; parts 2 and 3, 1878; vol. 2, pts. 1, 2, and 3, 1879; 4, 5, and 6, 1880.

Scientific Transactions. Vol. 1 (N.S). Memoirs, 1 and 2, 1877; 3, 4, 5, 6, 7, 8, 1878; 9, 10, 11, 12, 1880; vol. 2, part 1, 1879; part 2, 1880. *The Society.*

Journal of the Royal Historical and Archæological Association, Ireland. Vol. 5, No. 43, July, 1880.
The Society.

EDINBURGH.—Transactions and Proceedings Botanical Society. Vol. 14, part 1. *The Society.*

FLORENCE.—Atti Della Societa Toscana Scienza Naturale Processi Verbale. Adunanza del, di 14 Nov., 1880.

GORLITZ.—Abandlungen der Naturforschenden Gesellschaft zu Gorlitz Funfzehnter Band 1875, and Sechszhehuter Band, 1879. *The Society.*

HERTFORD.—Transactions Watford Nat. Hist. Society, and Hertfordshire Field Club. Vol. 2, parts 7 and 8, April and June, 1880. *The Society.*

HARVARD.—Bulletin of the Museum of Comparative Zoology. Vol. 8, Nos. 1, 2, and 3. Harvard College, Cambridge, Mass., U.S. *Alex. Agassiz.*

LAUSANNE.—Bulletin de la Societe Vaudoise des Science Naturelles. Vol. 17, No. 84. *The Society.*

LONDON.—Proceedings of the Zoological Society. Parts, 1, 2, 3, and 4, 1880.

Catalogue of the Library of the Zoological Society. *The Society.*

Journal Royal Microscopical Society. Series 1, vol. 2, Nos. 3, 4, 5, 6, 7, and 7a, 1879; vol. 3, Nos. 1, 2, 3, 4, 5, 6, and 6A, 1880.

Do. Do. Do. Series 2, vol. 1, parts 1 and 2, February and April, 1881. *The Society.*

Royal Astronomical Socy., Memoirs. Vol. 45, 1879-80. *The Society.*

LEIPSIG.—Sitzungsberichte Naturforschenden Gesellschaft zu Leipsig. Sechster Janrgang, 1879; and Nos. 1 and 2, 1880. *The Society.*

MANCHESTER.—Transactions Geological Society. Vol. 14, parts 14, 15, 16, and 17; Sessions 1879-80, 18 parts, vol. 15; Sessions 1878-79 and 1879-80, vol. 16, parts 1 to 5. *The Society.*

MAYNOOTH.—The Irish Ecclesiastical Record. Vol 1, parts 11 and 12, December, 1880. *Maynooth College.*

New York.—Bulletin of the American Geographical Society, U.S.A. No. 4 and No. 5, 1879; No. 1, 2, 3, 1880.
The Society.

Philadelphia.—Proceedings of the Academy of Natural Sciences, Philadelphia, U.S.A. Part 1, January, February, March, 1880; Part 2, April to September; Part 3, October to December, 1880.
The Academy.

Trieste.—Bolletino della Societa Adriatica di Scienze Naturali in Trieste. Vol. 6, No. 1, 1881. *The Society.*

Vienna.—Verhandlungen der K. K. Geological Reichsanstalt, 1877 to 1880, and Parts 1 to 7, 1881.
The Society.

Washington.—Geological Survey, Territories, U.S.A. Vol. 12.
Freshwater Rhizopods. Professor Leidy.
Eleventh Annual Report, 1877. By Haydon.
The Survey,

Smithsonian Institute, U.S.A. Annual Report, 1878.
Contributions to Knowledge, vol. 22.
Miscellaneous Collections, vols. 16 & 17.
The Institute.

Report of the Chief Signal Officer, War Department, 1879.
War Department.

DONATIONS TO MUSEUM—SESSION 1880-81.

From Colonel Crawford.

Impression of Bishop Hooper's Seal.
Medal in Memory of George IV.
Map of Ireland, 1572.
Two Pipes from Corfu.
Pipe Head.
Dagger from Albania.
Two Stone-handled Knives.
Coorg Knife, in Sheath.
Twenty-two Arrows of the Rhond Tribes, India.
Thorn of Acacia, from Jerusalem.
Three Tiger's Claws, India.
Scales of Fish, from Nerbudda River.
Engraved Bronze Drinking Cup, from India.
Necklace of Groo-Groo Nuts, Demerara.
Women's Dress, from India.
Indian Basket.
Flint and Steel for Striking Light, from China.
Flexible Sandstone, Agra.
Two Letters of Invitation from the Begum of Bhopal.
Painted Leather Bag.
Pair of Indian Mocassins, North America
Case of British Insects.
Snout of Sawfish.
A Large Centipede, and some Snakes.
Tail of Lyre Bird.

From Wm. Gray, Esq., M.R.I.A.

Portion of Basaltic Column, from the Giants' Causeway.
Ancient Wooden Dish, and a Large Ammonite.

From George Glen, Esq.

Specimen of Ironsand.

From Wm. Heron, Esq.

Shell, with Coral attached.

From John Musgrave, Esq.

Specimen of Laminated Mica Schist, from Carrick, Co. Donegal.

From Rev. J. G. Robertson.

Letter Written on Leaf of Palmyra Paper, from Ceylon.

From Mr. John Watters, Eastleigh, Strandtown.

A Stone Celt, some Copper and some Silver Coins.

From Mr. W. J. Robinson, Drogheda.

A number of Arrow-heads and Wrought Flakes, from Texas and Mexico ; also, some Fossils from Texas.

From Mr. James Harper, Dunadry.

A Pike-head, found in the thatch of an old house at Donegore, County Antrim.

From Fitzgibbon Louch, Esq., C.E.

Specimen of Native Sulphur, from the Lake at White Island, Bay of Plenty, Auckland, New Zealand.

From Mr. Wm. Thompson, Glenarm.

Antique Pewter Plate, manufactured in Dublin.

From Lieut.-General Smythe, R.A., F.R.S.

Specimen of Red Coral ; also, Model of Canoe, from Fiji Islands.

From Lord Clermont.

A number of Bird Skins, from Northern India ; also, two from Australia.

From Mr. Wm. Darragh.

Two Stuffed Birds, from India.

MUSEUM

OF THE

Belfast Natural History and Philosophical Society.

CATALOGUE OF THE COLLECTIONS.

CLASS I.—ANTIQUITIES.

Section I.—Irish Antiquities.

Displayed in Room 3, on Ground Floor. The specimens have been arranged in three Series.

Series I.—Objects of Stone.

Series II.—Objects of Metal.

Series III.—Objects of Wood, Bone, Earthenware, Glass, and Leather.

Series I.—Objects of Stone.

The *Stone Implements* included in this collection consist of articles of more or less ancient date, and display various degrees of skill and culture in the peoples by whom they were fabricated. They are intended to illustrate the life-history of the population of our country in former times. A large proportion of the objects here enumerated are pre-historic, and lead us back to a period when the arts of civilization had made but little progress, and the natives were content to array themselves in the skins of beasts slain by arrows, or by spears tipped only with flint. Whether palæolithic man found his way to Ireland seems, at present, to be an undecided question ;—but at all events this country was peopled at a very early date, when the rocks of our hills, and the boulders of our gravels, furnished the materials from which were fashioned the weapons employed in war and the chase, and the tools used in domestic occupations.

As might be expected, implements of stone form a conspicuous feature in collections of Irish antiquities, and the Belfast Museum is no exception, the cases containing numerous examples of the prevailing types. The flint implements number close upon a thousand, and include forms that range from rude flakes—precisely similar to those which, found elsewhere, are considered palæolithic—to arrow-heads of the utmost symmetry of form and delicacy of chipping. There is also a large series of the flints regarded as scrapers;—and the so-called hollow scrapers, so rare in other parts of Britain, are very well represented here, both in number and variety. The collection of arrow-heads is also good; all the forms are included, some of the examples being very fine. Flint spear-heads and celts are not so numerous. Of stone axes, or celts, there is a good display, the specimens varying much in size and finish. Stone whorls, sinkers, whetstones, etc., are fairly represented;—as also various kinds of querns, or hand-mills, by which anciently the corn was ground into meal.

NOTE.—*The Specimens to which the letter "B" is prefixed, viz.:—B1 to B1,135 were presented to the Society by the late George Benn, Esq., of Fortwilliam Park, Belfast. They were found chiefly in the County of Antrim, and are arranged in the wall case, on the west side of the room.*

1 to 7 unmounted, and B1 to B56, mounted on cards 1 and 2.

Rude Flint Flakes, that show no secondary chipping. B12, B21, and B30, are roughly tanged, as if for the purpose of being affixed to hafts. Nos. 8 to 12 unmounted;—size, 1½ to 4 inches long.

8 to 12 unmounted, and B57 to B100, mounted on cards 3 and 4.

Flint Flakes, having the same general characters as the preceding, but more or less chipped on the edges—B71 has lateral indentations near the base, as if for securing it to a handle. No. 12 and B72 and B73 are rudely stemmed or tanged. Size, 1¼ to 4½ inches long.

The flakes referred to above, though rude and unpolished, yet required a considerable degree of skill for their manufacture. They were dexterously struck off pieces of flint by means of

another stone. Some of the lumps of flint from which flakes have been made are occasionally found, and are called cores. The undressed flakes are supposed to have been applied to several purposes, serving as knives for domestic use, and as spear and arrow heads in the chase and in war.

Flint Scrapers. These have been struck off the stone in the same manner as the flakes previously described ; but, instead of the sharp point and cutting edge, they have a thick end, which has been chipped so as to have a rounded contour, convex on one side and flat on the opposite face. These implements seem suitable for scraping down the hides of animals, out of which the clothing of that remote period was formed. Another class of scrapers consists of those curious flints called hollow scrapers: in these the scraping edge is concave, and generally serrated by fine chipping. The object of these implements is not clearly ascertained, but it has been suggested that they served for scraping smooth the small branches of trees from which arrow and spear shafts were made. See plate 1, figs. 1, 2, 3, 4, 5, 6, 7.

13 to 18 unmounted, and B101 to B246, mounted on cards 5, 6, 7, 8, 9.

Oval or Elongated Scrapers, chipped round the margin, on the thick convex side or back, and displaying the "bulb of percussion" on the more or less flat face. B225, B226, B228, B229, B234, and B244, are rudely tanged, or stemmed ; B219 and 235, are figured on plate 1, figs. 1 and 2. Size, $\frac{3}{4}$ to 4 inches long, $\frac{3}{4}$ to $2\frac{3}{4}$ inches broad.

19 and 20 unmounted, and B247 to B264, mounted on card 10.

Transversely oblong Scrapers, sometimes called *Side Scrapers*. One of the longer margins is usually thin and unchipped, the opposite side being much thicker, rounded on the back, and chipped. Some, however, have both margins chipped. B263 is figured on plate 1, fig. 3. Size, $\frac{3}{4}$ to $1\frac{3}{4}$ inches long, $1\frac{3}{4}$ to $3\frac{1}{2}$ inches broad.

B265 to B357, mounted on cards 11, 12, 13.

Flint Implements, styled by Dr. John Evans, F.R.S., *Hollow*

Scrapers (*vide* "Evans's Ancient Stone Implements of Great Britain," fig. 226, p. 257). These specimens consist of thin flint chips, more or less square in outline. The face displays the bulb of percussion, while the opposite surface has a corresponding concavity, the chips being, apparently, struck off the stone in regular series. The distal edge, opposite the bulb, is thin and crescent-shaped, the margins, in different specimens, representing segments of circles of various diameters, which are usually finely serrated, though in some instances they are quite entire. B304 has two hollow scraping edges, and its base is thick, and chipped as in ordinary scrapers; B319, B324, B347, and B354, also show chipping on the back; B321 and B325 have each two crescent-shaped scraping margins. Size of longest specimen, 2½-in. long, 1¾ broad. The broadest specimen is 2¼. inches broad, 1¼ long.

B297, B304 and B319 are figured on plate 1, figs. 4, 5, 6,
B358 to B387, mounted on card No. 14.

Flint Implements of various form and purpose. B358, B359 and B364 are triangular flints, which may have served both as scraping and cutting tools. They have each one or two sharp cutting edges, and a thicker base, which has the secondary chipping of an ordinary scraper. Similar to fig. 7, "Royal Irish Academy Catalogue." B360, B361, B362, B363, B365, B366, B367, B368 and B369 seem to combine, in each specimen, the purposes of cutting and boring. They are 2 to 3 inches long, and ½ to ¾ inches broad, with the back thick, and chipped to a scraping surface, and the opposite edge thin, sharp, and unchipped. In these implements one end tapers to a blunt point, while the other extremity is chipped into a rude awl-shaped form. B375 is a broad thin flake, with coarsely jagged edges; B376 is a flat implement, rectangular in outline, and chipped all round, 2½ by 2 inches. B359 is figured on plate 1, No. 7. 24 is a sharp pointed flake, coarsely chipped on the flat side, and having a small rounded notch at the base, as if for scraping small objects like bone needles. Length, 3 inches; breadth, ¾-inch.

Flint Knives. Flint being a very hard substance, which naturally chips to a thin edge, it has from the earliest times been used to form knives. These have assumed various forms, the type mounted on card No. 16, being the most graceful form, and displaying the most artistic finish. The makers of these flints possessed the art of taking off a thin curved chip of flint transversely across the rounded back of the knife-blade.

B388 to B411, mounted on card 15.

Oblong Shaped Flints—Knives and various. These specimens show the bulb of percussion on the face, which is flat and unchipped. On the back, or convex surface, they are chipped, some elaborately, others less so. In many of these flints the process of manufacture seems to be only partially completed. Size, $1\frac{3}{4}$ inches to 4 inches long.

No. 21, Flint Knife, like that represented by fig. 249, Evans's "Stone Implements," but our specimen has not been finished. No. 25, Flint Knife blade, oblong-oval in outline, and quite symmetrical. One surface is flat and unchipped, the opposite side is convex, rounded off to a sharp cutting edge, and most delicately chipped. Length, $2\frac{1}{4}$, breadth, $\frac{3}{4}$ inches.

B412 to B441, on card 16.

Knife-bladed Flints, resembling the preceding—perfect in form, and exquisitely chipped on the convex surface. The margins curve symmetrically to a more or less acute point at each extremity. Fig. 239 of Evans's "Stone Implements" represents, but does not do full justice to this type. Size, $1\frac{3}{4}$ to $2\frac{3}{4}$ inches, $\frac{5}{8}$ to $1\frac{1}{4}$ inches broad.

Arrow-heads. The use of the bow and arrow in war and the chase has prevailed in very ancient times, and still continues amongst many savage tribes, and the use of some kind of stone for points of arrows seems to have been equally wide-spread and enduring. On account of its hardness, some silicious material has always been preferred; even bottle glass is often made to serve the same purpose. Excellent arrow-points are made of obsidian, but the material always employed by the ancient

workers, where obtainable, has been flint. The supply of flint in the North of Ireland being inexhaustible, seems to have led to an extensive manufacture of arrow-heads, as well as other flint implements, in this locality. In no other part of Britain have flint arrow-heads been found so abundantly, and the skill of the ancient Irish workers in flint has nowhere been excelled. These weapons have been formed with a degree of symmetry, and finished with a delicacy of touch, that could not be exceeded. The flint arrow-heads have been divided into several leading types : they pass up into javelin and spear-heads, which assume the same forms.—See plate 1, figs. 8 and 9.

B442 to B468, mounted on card 17.

Worked Flints, of various forms and dimensions. They seem to represent spear and arrow-heads in an unfinished state, or some may have been rejected as unfit for completion. All the forms of arrow-heads are represented on this card by rude examples. Some are triangular, some indented, others stemmed, barbed, leaf shaped, or lozenge shaped. Size, 1 to 4 inches long.

No. 23 is a rude, or unfinished arrow-head. It has been worked roughly into the leaf shape, but lacks the fine chipping characteristic of that type. "Evans," fig. 246, represents a specimen almost identical. Length, $2\frac{1}{4}$, breadth, $1\frac{3}{4}$ inches.

29 to 33 unmounted, and B469 to B508 mounted on card 18.

Triangular Arrow-heads, varying from triangular with entire base to the indented form. The notch worked in the latter is sometimes quite shallow, in other specimens it appears as a deep sinus. B474 and B475 are chipped on one surface only, the opposite side being flat and flake-like. Size, $\frac{7}{8}$ to 2 inches long.

34 to 37 unmounted, and B509 to B536 mounted on card 19.

Stemmed Arrow-heads. The stem or tang varies in size. Some, as No. B518, are beautifully serrated on the edges. Size, $1\frac{1}{2}$ to $2\frac{1}{2}$ inches long.

26 to 28.

One Triangular-Indented and *Two Stemmed Arrow-heads*

found at Ballinderry, County Antrim. About 1½ inches long and 1 inch broad.

B537 to B560, mounted on card 20.

Javelin-heads, or *Large Arrow-heads*, stemmed as in the preceding. Some of these, as B553, are rudely made, and without lateral wings. Others are wrought with much skill. B546 and B553 are figured on plate 1, Nos. 8 and 9. Size, 2 inches to 3½ inches long.

B561 to B612, mounted on card 21.

Barbed Arrow-heads, varying much in form, and also in finish. Some are exquisitely wrought, while others are comparatively rude. B604 is a broken specimen, remarkable for the great size of its barbs and the manner in which they spread. The length of this arrow-head was less than its breadth, when unbroken. Size, ¾ to 1¾ inches long.

38 to 41 unmounted, and B613 to B647 mounted on card 22.

Leaf-shaped Arrow-heads. Many of these are examples of the finest character of work: slender, and of elegant proportions, and with most delicate chipping; others are coarser and less symmetrical. B640 is produced at the base into a stem or tang, for inserting in the shaft. No. 39 is exactly represented by fig. 293 of Evans's "Stone Implements." Size, 1½ to 2 inches long.

42.

Javelin-head, of elegant proportions and exquisite workmanship. It is lozenge-shaped, and one of the best examples of this graceful type. Evans, fig. 276, illustrates this form admirably. Length, 4 inches; breadth at the shoulder, 1¼ inch.

B648 to B680, mounted on card 23.

Lozenge-shaped Arrow-heads, mostly of elegant proportions, and chipped with the utmost skill. Size, ¾ to 2½ inches long.

43.

Leaf-shaped Spear-head, coarsely worked over the surface, but with somewhat finer chipping on the margins. Identical

in size, form, and workmanship, with the specimen from Le Moustier Cave, in the Dordogne, represented by fig. 1, plate A, 3, "Reliquiæ Aquitanicæ." Length, $4\frac{3}{8}$; breadth, $2\frac{1}{4}$ inches.

B681 to B693, mounted on card 24.

Spear-heads, of various form and size. Some are oval, some leaf-shaped, and others of the lozenge-shaped type. B683 has been a fine weapon, but is broken. B690 is a remarkably fine example, made from the variegated flint that occurs at the upper surface of the chalk, where it is in contact with the trap rock. This specimen is of the lozenge pattern; it measures $7\frac{1}{2}$ inches in length, and has the surfaces ground and polished. Sizes, very various.

22.

A *Worked Flint*, which seems to combine the characters of spear-head and knife. It is equally convex on both surfaces, which are chipped all over, the margins being worked to a sharp cutting edge. The base, which is square, is especially sharp, and ground on one side. The specimen resembles fig. 341 of Evans's "British Stone Implements."

44.

Oblong *Flint Celt*, very roughly chipped, except in front, which has a smooth, nearly straight axe-like edge. Length, $5\frac{1}{2}$; breadth, $2\frac{1}{2}$ inches.

45.

Flint Celt similar to the preceding, but having a semicircular cutting edge. Length, $5\frac{1}{2}$; breadth, 2 inches.

46.

A small *Flint Celt*, much narrowed to the base, as if for inserting in a handle. The narrow end is rough and unpolished, but the broad, rounded, axe-like edge has been ground smooth and sharp. Length, 3 inches; greatest breadth, 2 inches.

$46\frac{1}{2}$.

A *Celt-like Cutting Tool*, abruptly truncate at the base, which is not narrowed. Fig. 29 of Catalogue of Royal Irish Academy represents a similar implement.

B694 to B698 mounted on Card 25.

Celts, or *Hatchets*, made of flint. They have the cutting edges ground and polished. Size, $4\frac{1}{2}$ to $7\frac{1}{4}$ inches long.

B699 to B706 mounted on Card 26.

Flint Implements of various forms and uses. B699 is a massive, coarsely-worked implement $3\frac{3}{4}$ inches long, by $1\frac{1}{4}$ broad and 1 inch thick, pointed at each end, as if intended for a punch or small pick. B700 is of the same type, but only 2 inches long. B701 and B702 seem to be cores from which flakes have been struck off. B703 is a broken specimen of a rude unground celt. B704 and B705 are remarkable lenticular discs of flint, nearly circular in outline, and about $2\frac{3}{4}$ inches in diameter. They are ground smooth on both surfaces, polished, and brought to a moderately fine edge all round. B706 is a flint chisel similar to No. $46\frac{1}{2}$. It has the proximal edge ground fine and the butt-end abruptly truncate. Size, $3\frac{1}{2}$ inches long, by $2\frac{1}{2}$ broad.

Stone Whorls. Various uses have been assigned to these objects. It has been suggested that they served as dress-fasteners (links), as beads, as sinkers, as counters for some game, and as spindle whorls, when yarn was spun by means of the distaff, ere the invention of the spinning-wheel. The latter is the commonly received opinion.

47 to 49.

Perforated Stone Discs, or Whorls. 47 is of hard shale, and is ornamented on each surface with two circles of ovate to rhomboidal markings. Size, 1 inch to $1\frac{1}{2}$ inches diameter. They were dug up in an island in Lough Clay, County Down, in 1845.

50 to 58.

Perforated Whorls, of sandstone and shale. 53 is marked on one side with fine punctures. No. 54 has a series of incised concentric circles. Diameters, $1\frac{1}{4}$ to 2 inches.

B707 to B740, mounted on card 27.

Perforated Stone Discs, or Whorls. Mostly rough and unpolished. With a few exceptions, they are formed of sandstone

and shale. The lowest row on this card are, more or less, globular in form, and of smaller size. Diameters, ½ inch to 2¼ inches.

B741 to B760, mounted on card 28.

Whorls which, like the preceding, are formed mainly of sandstone; a few are of shale. B745 is of earthenware. B757, B758, B759, have the perforations enlarged and worn down to one side, as if by the working of a spindle. B760 has a small hole drilled near the margin, apparently for suspension. These whorls are either slightly concave, quite flat, or convex on one or both faces. Diameters, 1½ to 2½ inches.

B761 to B785, mounted on card 29.

Stone Whorls. Mostly polished, and of symmetrically rounded shape. B762 and B763 are decorated by carved ornamentation, consisting of lines and dots on their faces. Several other specimens on this card show incised concentric lines. B766 is a quartz nodule, with natural perforation, but has evidently been preserved for use. Diameters, ¾ inch to 1½ inches.

Stone Celts.—These are implements intended to serve the same purposes as the metallic axes, hatchets, adzes, and chisels of the modern artificer. The word celt is derived from the Latin, *celtis*, and literally signifies a chisel. A small portion only of the celts are chisels in the modern sense, but the term is used as generic, and includes all the cutting tools of the joiner. Stone celts are found in all parts of the world, and are popularly regarded in most countries as thunderbolts. In Ireland they are abundant, and large numbers have been found in Down and Antrim. (See Plate 1. fig. 10).

59.

Celt, or *Stone Axe*, made of a fine-grained silicious rock, and highly polished. This is an excellent example of its class. Each of its sides has been ground flat. The front or cutting edge is about three inches wide, and the equally sharp base 1½ inches. Length, 14; greatest breadth, 3¼ inches. Found in a bog near Portglenone, 1848.

60.

Celt, massive and highly polished. The cutting edge is much

rounded, and the base produced to a pick-like point. Length, 13; greatest breadth, 4 inches.

61.

Celt of oval-oblong form, made of trap rock; both extremities present cutting edges. Length, 7; greatest breadth, $3\frac{1}{4}$ inches. Found at Kilrea, County Derry.

62.

Celt made of quartzite rock, and finely polished. The sides are ground flat. Length, $6\frac{1}{2}$; breadth, $2\frac{3}{4}$ inches. Found at Malone, near Belfast.

63.

Celt, highly polished. The cutting edge broad, and the butt-end pick-like. Length, $6\frac{1}{2}$; breadth, $2\frac{3}{4}$ inches. Found in County Armagh.

64.

Celt, polished and flat-sided. Length, $3\frac{1}{2}$; breadth, $1\frac{3}{4}$ inches. Found in County Armagh.

65.

Celt, found at Saintfield, County Down. Length, 3; breadth, $1\frac{3}{4}$ inches.

66 to 108.

Polished Stone Celts, of various sizes, and different degrees of excellence. No. 67 is a massive celt of unusual form. It is of hard quartzite, straight, and nearly equally broad at both ends. The thick rounded base is considerably bruised and broken. It is like fig. 62 of Evans's "Stone Implements," but the butt end of our specimen is thick and hammer-shaped. It is 6 inches long, $2\frac{1}{4}$ broad, $1\frac{5}{8}$ thick. 94 is an adze-like form, being made from a curved piece of stone.

109.

A *Celt* of almost triangular form, with a straight, sharp cutting edge. It closely resembles fig. 42 of Evans's "Stone Implements."

B786 to B990.

Polished Stone Celts, or *Axes*, made of various kinds of rock, the best specimens being quartzites and porphyries. These implements are of very different sizes. The smallest speci-

men measures $1\frac{1}{8}$ inches long, by $1\frac{1}{8}$ broad at the cutting edge, while the largest example is $11\frac{1}{2}$ inches long, by 4 broad. The average or prevailing size is from 4 to 5 inches long.

B991 to B1,004.

Narrow-shaped Celts, or *Chisels*. The stones are polished, and they have cutting edges similar to the preceding. Size, $3\frac{1}{2}$ to $4\frac{1}{2}$ inches long, $1\frac{1}{4}$ to $1\frac{1}{2}$ broad.

110 to 112.

Small Stone Chisels. 110 is a thin flat implement, 2 inches long by 1 inch broad; 111 and 112 are fragments of thick, narrow, rounded tools, like fig. 73 of Evans's "Stone Implements."

113.

Chisel, or *Pick*. This finely polished implement is thickest and broadest at the middle, and is brought at the point to a sharp cutting edge, only $\frac{1}{2}$ inch broad. Length, $4\frac{1}{2}$; breadth in the middle, $1\frac{1}{8}$; thickness, $\frac{7}{8}$ inches. Found in Tory Island, County Donegal.

B1,005 to B1,018.

Polished Stone Celts, having a form somewhat adze-shaped. One surface is either concave or else quite flat, while the opposite face has the usual rounded outline of an ordinary celt. No. B1,018 is figured on plate 1, No. 10. Size, 3 to 5 inches long; $1\frac{1}{2}$ to 3 inches broad.

B1,019 to B1,027.

Rude stone *Celts*, which are either entirely unpolished, or else have merely the edge slightly ground. Size, $3\frac{1}{2}$ to 5 inches long.

139.

Axe-hammer, rectangular in section, and perforated above the centre for insertion of shaft. The base is hammer-shaped, and the opposite end has been ground to a vertical, axe-like edge. Length, 13; breadth at middle, 4; thickness, 3 inches.

140.

Axe-hammer, like the preceding, but having a rounded instead of a square section. Length, 11; breadth 4; thickness, $2\frac{1}{2}$ inches. Found in a bog in County Down.

B1,028.

Oval-shaped *hammer*, made of trap-rock. It is perforated for a shaft, and is flattened at the extremities by use. Size, $4\frac{1}{2}$ inches long, $1\frac{3}{4}$ thick.

B1,029.

Quartzite perforated *hammer*. Size, $3\frac{1}{2} \times 2 \times 1\frac{3}{4}$ inches.

B1,030.

A curious perforated *hammer*. It is nearly cylindrical, with both faces symmetrically rounded, and showing no traces of wear. Resembles Fig. 151 of Evans's "Stone Implements." Size, 3×2 inches.

B1,031.

Perforated sandstone *hammer*; questionably authentic. Size, $10\frac{1}{2} \times 3\frac{1}{2} \times 3\frac{1}{4}$ inches.

134

Is a broadly oval implement of the class designated in the Catalogue of the Royal Irish Academy as *punch-hammers*. The anterior margin has been ground to a rounded axe-edge, while the butt-end is thick and blunt. It is encompassed by a broad, flat groove above the base. A thong secured in this furrow would afford the means of holding the tool while being struck by a maul.

130.

A flat stone of hard slate, roundly triangular, polished smooth, and perforated at one of the angles; most likely a slickstone or polisher. Dug up near Killyleagh, County Down, in 1845.

131.

A *Sinker* or *Plummet* of coarse schist. It is an oval-shaped pebble, in which a hole has been made at one end. Length, $4\frac{1}{2}$; breadth, $2\frac{3}{4}$ inches.

B1,032.

Perforated Sandstone Hammer. Size, $3 \times 2\frac{1}{2} \times 1\frac{3}{4}$ inches. Questionably genuine.

B. 1,033 and 1,034.

Stone Sinkers, with groove around the centre; possibly forgeries.

B1,035.

Small Sandstone Pounder. Size, 3 x 1¾ inches.

B1,036 to B1,038.

Implements formed of Schist. Somewhat like celts; intended to be used by grasping in the hand. Perhaps spurious.

B1,039.

A Hammer or *Pounder*, with a shallow transverse groove, as if for using with a thong. Size, 7 x 3½ inches.

B1,040.

A dumb-bell-shaped instrument of gneiss rock; perhaps a *Sinker.* 12 inches long. May not be genuine.

135 to 138.

Perforated *Hammer-stones* (*Tilhuggersteene*); circular or oval in outline. 136 is deeply countersunk on each side, but is not quite perforated:—Diameter, 2¼ to 3½ inches.

B1,041 to B1,088.

Hammer-stones (*Tilhuggersteene*), made of various kinds of stone, and more or less oval or ovoid in form. Many of the specimens are perforated for shafting; others are imperforate, but have deep hollows on each face; while many, especially the large hammers, show only comparatively slight concavities. The latter are well represented by Plates 13A, and Plate 23A of "Reliquiæ Aquitanicæ." Size, from 2 x 1½ inches to 6 x 4 inches.

Querns.—Previous to the construction of the modern corn-mills, the grain was made into meal by means of hand-mills, designated querns. The simplest and most ancient form is the saddle-quern, like B1089, which consists of two pieces—a large flat slab, somewhat concave on the upper surface, and a smaller crushing-stone, which is plano-convex. The grain, being placed on the lower stone, is reduced to meal by means of the rubber. The ordinary and more modern querns have the top stone, or rider, rotated upon the lower by means of a handle, and the pot-quern has the lower stone deeply hollowed out, so

that the rider works in a cavity surrounded by a rim. This primitive manner of grinding corn is still in use in many parts of the world.

114.

Upper Stone of Quern, made of micaceous grit, convex above, flat below. There are two perforations—one marginal, for the insertion of a handle, and one central and funnel-shaped, to admit the grain. Diameter, 14; thickness, 5 inches.

115.

Upper Stone of Quern, made of sandstone. It is disc-shaped, and has a central and four marginal holes. Diameter, 14 inches; thickness, 2½ inches.

116.

Upper Stone of Quern, similar in size and form to the preceding, but more rudely formed, and but one lateral aperture.

117.

Upper Stone of Quern, made of sandstone, but of the same type as the preceding. Diameter, 19; thickness, 2½ inches. The three last specimens were found in a bog at Maghera, County Derry.

118.

Upper Stone of Quern, of coarse granite, and very rude. Diameter, 18; thickness, 3½ inches. Found in County Down.

119.

Upper Stone of Quern, similar to 114. Diameter, 13; thickness, 5 inches. Found at Saintfield, County Down.

120.

Upper Stone of Quern, like the preceding. It has had two lateral holes for handle, but one has broken out in use. Diameter, 13½; thickness, 4½ inches. Found in a bog at Randalstown, County Antrim.

121.

Upper Stone of Quern, of same type as the preceding. A very fine, massive example, having carved decoration on its convex surface. Diameter, 14½; thickness, 5½ inches.

122.

Upper Stone of Quern, having the same general characters as

the preceding, but rudely made of coarse granite. It has the central funnel-shaped aperture, and several small holes for handles, scattered irregularly over the surface. In this much-worn specimen many of the holes had broken out, and thus new ones had to be sunk as required. Diameter, 14; thickness, 4 inches.

123.

Upper Stone of Quern, rudely formed of granite. Diameter, 12; thickness, 2½ inches.

124.

Pot Quern, made of sandstone. The lower stone stands on three legs, and the stone is hollowed out, so as to leave a pot-like cavity above, in which the rubbing-stone was rotated. The upper stone is two inches thick, and has a central aperture. The lower stone is perforated in the centre and the margin. Diameter, 10; height, 6 inches.

125.

Lower Stone of Pot Quern, similar to the preceding. Diameter, 10; height, 4 inches.

126.

Upper Stone of Pot Quern, made of sandstone. Size, 8½ x 2 inches.

127.

Rubbing Stone of Saddle Quern, made of granite; oval in shape, and plano-convex in section. Size, 15 x 10 x 2½ inches.

128.

Grain Rubber, similar to preceding. Size, 8½ x 7 x 2 inches. Found at Ballintoy, County Antrim, 1881.

B1,089.

The Lower Stone of a Saddle Quern. It has a flat under-surface and concave upper surface, which shows evidence of having been used. The material is micaceous schist. Size, 23 inches long, 14 broad, and 2 to 3 inches deep.

B1,090.

The Upper or Rubbing-stone of a Saddle Quern, made of coarse, reddish grit. Size, 10½ inches by 8½ broad.

B1,091

This is also a *Rubbing-stone.* It is made from a fine-grained grit. Size, 9 inches by 7.

B1,092.

Upper Stone of Quern, made of hard, coarse-grained trap-rock. There is a central, funnel-shaped perforation for admission of grain, and also a hole at one side for insertion of handle. Size, 12 inches long, 9 broad, and 3 to 5 inches thick.

B1,093.

Lower Stone of Quern. This is a massive block, with a convex under-surface. The upper side is concave, and has a central perforation. Size, 21 inches long, 15 broad, and 5 inches at thickest part.

B1,094.

Upper Stone of Quern, circular and perforated. Diameter, 6½ inches.

B1,095.

The Lower Stone of a Pot Quern. It stands on three feet, and has a central and also a lateral perforation. Diameter, 8 inches.

B1,096.

Upper Stone of Small Quern. Diameter, 4½ inches; thickness, 2 inches.

B1,097.

Complete Pot Quern, made of sandstone. The lower stone stands on three feet, and is perforated in the centre, and also at the margin. The upper stone is two inches thick, and has a central perforation for feeding with grain, and two holes sunk near the margin. Diameter, 10 inches; height, 5 inches.

B1,098 to B1,100.

Portions of Querns.

129.

Millstone of hard grit, and furrowed on the surface, as in modern stones. Diameter, 23; thickness, 3½ inches. Found in a bog at Maghera, County Derry.

B1,101 to B1,103

Round Stones, with deep cup-shaped hollows on the upper surface. They resemble small mortars in form. Size, 2½ to 3½ inches in diameter.

B1,104.

A *Ball of Sandstone*, having the shape of an orange, and with broad furrows passing around it vertically. Diameter, 2¾ inches.

B1,105

A *Chisel-shaped Implement*. There is a hole for a cord to pass through, and the edge is oblique, and quite sharp. Size, 3 inches long, 1¼ inches broad.

B1,106.

A *smooth polished Implement* of oblong form ; seems adapted for rubbing or polishing. Size, 5½ iuches long, by 1¼ at the centre.

B1,107.

An *oblong Implement* of hard stone. It is somewhat polished ; thin and knife-edged all round. Size, 6¾ inches long, by 1¼ at the broadest part.

B1,108

A *spherical object* of hard stone, smooth and polished. Size, 1½ inches in diameter.

B1,109 to B1,111.

Oblong Implements, with flat polished surfaces, as if for rubbing or burnishing. They have been perforated so as to attach to a cord. Size, 2½ to 4 inches long ; width, about one-half.

B1,112 to B1,115.

Oblong Burnishers, perforated at each end. No. B1,066 is of coarse grained stone ; the others are extremely fine, and polished smooth. Size, 2 inches to 3¼ in length ; ½ to 1 inch broad.

B1,116.

A *Rubbing-stone* or *Burnisher*, convex on one surface, and

quite flat on the other. It is finely polished, and is perforated at one extremity, and has a hole at the other end, which does not perforate the stone. Size, 3 inches long, by $\frac{3}{4}$ at the broadest part.

B1,117

A *Rectangular Burnisher*, perforated at one end. Size, 3 inches long, by $\frac{5}{8}$ broad.

B1,118 to B1,123

Whetstones, with perforations at the end. Size, 2 inches to $3\frac{1}{2}$ long, $\frac{1}{2}$ to 1 inch broad.

B1,124 to B1,127

Imperforate Whetstones. Size, 2 to 3 inches long, $\frac{1}{2}$ inch broad, and $\frac{1}{2}$ inch thick.

150.

Whetstone of fine slate. Size, 3 x 1 x $\frac{3}{8}$ inches. Found at Killiney Lough, County Down, 1839.

132.

A *Touchstone*, or possibly a polishing tool, of reddish coloured quartz. It is rectangular, tapering to each extremity, and quite smooth. It is exactly represented by Fig. 71, Royal Irish Academy Catalogue. Length, 3 inches; breadth and thickness at the middle, $\frac{5}{8}$ inch.

B1,128 to B1,133,

Smooth, Flattened Stones, nearly circular in outline, and rounded off to the margins. On each face there is a shallow groove, extending to rather more than half the diameter of the specimen. They are of smooth quartzite rock, except Nos. B1,086 and B1,087, which are of coarse sandstone, and possibly only modern imitations. Diameter, about 2 inches; thickness, 1 inch.

142.

Sandstone Mould for casting bronze celts. This is a thick piece of sandstone, with moulds for flat celts on three faces.

The moulds measure 6 inches, 5 inches, and 3 inches respectively. A fourth mould, measuring 4 inches, is now nearly obliterated. Found at Ballynahinch, County Down, 1843.

143.

Fragment of Stone Mould. This has been used for casting various metallic objects, and the stone has thus become quite black. On one side is the mould of a small cross; two others are of round objects like coins or medals. Breadth, 2 inches; thickness, $1\frac{3}{4}$ inch; the fragment that remains is $2\frac{1}{2}$ inches long. Found at the Antrim Round Tower.

B1,134 and B1,135

Quartzite Boulders, which have been used as journals or bearings for spindles of comparatively modern mill machinery. Deep, finely-polished holes have been worn in the stone by the metal spindles. They are, of course, of modern date.

141.

Granite Journal of Corn Mill. Same as the preceding.

144.

Fragments of the Roof of the Round Tower formerly existing at Trummery, County Antrim.

145.

Block of Sandstone, bearing on its principal face an Irish Cross, sculptured in relief. There are also five smaller incised croses on the stone. Length, 13; breadth, 5; thickness, 3 inches. Found near foundations of the old church at Bangor, County Down.

146 to 149.

Marble Carvings of Scriptural Subjects. The workmanship, which is exquisite, is probably Italian, of the 16th century. Size, 5 x $3\frac{3}{4}$ inches. Found at the ruins of the Abbey of Na Fearta, Armagh.

151 and 152.

Stone Beads, or *Whorls.* 152 has been turned, and bears incised lines. Diameter, 1 inch.

153.

Jet Armlet, dug up in a bog at Derryavilah, 1866. Diameter 4 inches.

154.

Portion of Massive Jet Armlet.

155.

The *Flat Plate of a Jet Necklace*, marked with series of punctures. See Fig. 375, Evans's "Stone Implements." Found near Carrickfergus.

156 to 160,

Stone Beads. 159 and 160 are encrinite joints, which have been used as beads. Diameter, $\frac{1}{2}$ to 1 inch.

133.

Flat Stone, having a rhombic outline. It is perforated horizontally by a series of five slits, so narrow that they will not admit a penknife blade. The use of this object is unknown. Size, $1\frac{5}{8}$ x 1 x $\frac{5}{8}$ inches.

161.

Grave Slab, made of sandstone, and sculptured with florid cross, &c. Found at old burial-place, Ballymechin, near Holywood, County Down.

162.

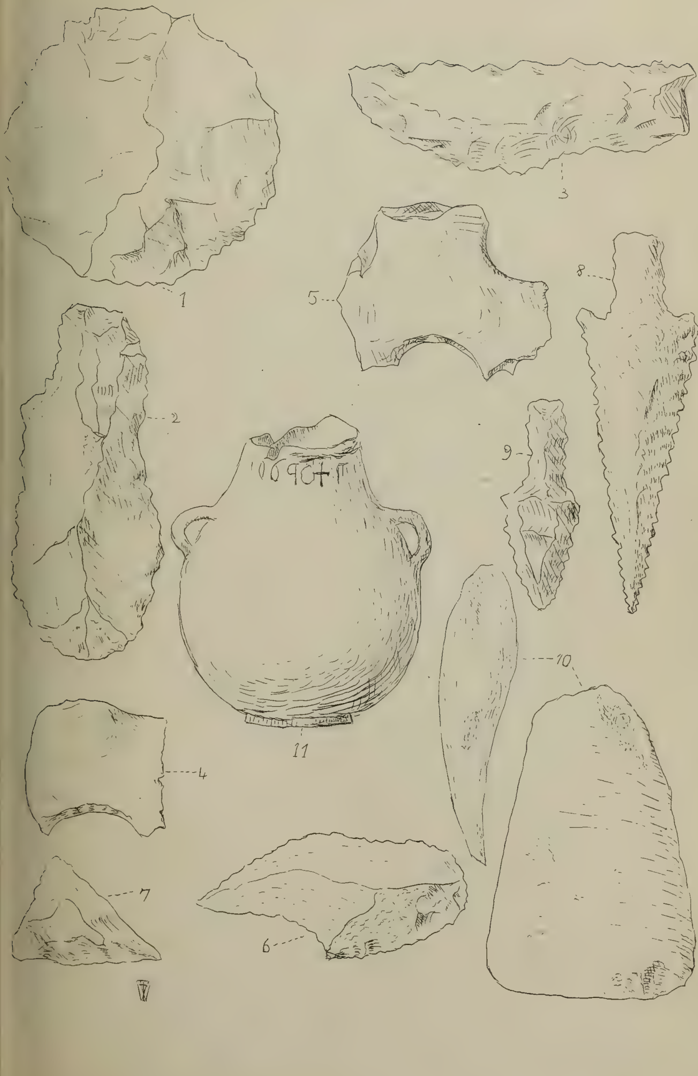
Cup-marked Stone. This is a large slab, on which a number of irregular, scattered cup-like hollows have been made. Use unknown. Found at Drumsurn, Balteagh, County Derry.

163.

Square Stone, with inscription. Taken from the old "Long Bridge" of Belfast when it was being demolished. Size, 16 x 11 x 8.

EXPLANATION OF PLATE I.

Fig. I.—Flint Scraper, almost circular. B219.
Fig. II. Do elongated form. B235.
Fig. III. Do. transversely elongated form. B263.
Fig. IV.—Hollow Flint Scraper, typical form. B297.
Fig. V. Do. Do. Double Scraper. B304.
Fig. VI. Do. Do. chipped on the back. B319.
Fig. VII.—Triangular Flint Scraper and Knife. B359.
Fig. VIII.—Spear or Arrow-head, serrated on the edges. B546.
Fig. IX. Do. Do. rude, and not barbed. B533.
Fig. X.—Stone Celt, adze-like form. B1,018.
Fig. XI.—Bronze Altar Vessel from Islandmagee. Series 2. B5.


1
2
3
4
5
6
7
8
9
10
11

PROCEEDINGS

OF THE

BELFAST

Natural History and Philosophical Society,

FOR THE

SESSION 1881-82.

BELFAST:
PRINTED BY ALEXANDER MAYNE, CORPORATION STREET.
(PRINTER TO THE QUEEN'S COLLEGE.)

1882.

PROCEEDINGS

OF THE

BELFAST

Natural History and Philosophical Society,

FOR THE

SESSION 1881–82.

BELFAST:
PRINTED BY ALEXANDER MAYNE, CORPORATION STREET.
(PRINTER TO THE QUEEN'S COLLEGE.)

1882.

CONTENTS.

Belfast Natural History and Philosophical Society.

ESTABLISHED 1821.

SHAREHOLDERS.

1 Share	in the Society	costs	£7.
2 Shares	,,	,,	cost £14.
3 Shares	,,	,,	cost £21.

The proprietor of 1 Share pays 10s. per annum ; the proprietor of 2 Shares pays 5s. per annum ; the proprietor of three or more Shares stands exempt from further payment.

Shareholders only are eligible for election on the Council of Management.

MEMBERS.

There are two classes, Ordinary Members, who are expected to read Papers, and Visiting Members, who, by joining under the latter title, are understood to intimate that they do not wish to read Papers. The Session for Lectures extends from November in one year till May in the succeeding one. Members, Ordinary or Visiting, pay £1 1s. per annum, due first November in each year.

PRIVILEGES.

Each Shareholder and Member has the right of personal attendance at all meetings of the Society, and of admitting a friend thereto ; also of access to the Museum for himself and family, with the privilege of granting admission orders for inspecting the collections to any friends not residing in Belfast.

Any further information can be obtained by application to the Secretary. It is requested that all accounts due by the Society be sent to the Treasurer.

The Museum, College Square North, is open daily from 12 till 4 o'clock. Admission for strangers, 6d. each. The Curator is in constant attendance, and will take charge of any Donation kindly left for the Museum or Library.

BELFAST

Natural History and Philosophical Society.

ANNUAL REPORT, 1882.

The Council for the past year, appointed by the Shareholders at their annual Meeting, on the 7th June, 1881, desires to lay before them its Report on their property, and the other interests of the Society.

The Museum collections are in very good condition, and much has been done during the past year by your curators, with the assistance of some members of the Society, in the way of re-arranging and labelling the specimens ; much progress has also been made in the preparation of a catalogue of the collections, the first part of which has been published this year.

The employment of two curators, although of undoubted advantage, has entailed considerable additional expense on the Society, which your Council regrets to say, has not yet been met by any adequate increase of shareholders and subscribers.

A number of specimens have been added to your collections during the past year, a list of which will be given at the end of this report.

With regard to your library, the librarian has had the books re-arranged and a full catalogue made of them, which he is in a position to publish whenever desired. We continue to receive, in exchange for our transactions, reports of proceedings from the various leading philosophical and scientific societies in Europe, Asia, Australia, and America; a list of these publications is appended to this report.

On Easter Monday the Museum was thrown open to the public, as has been customary for many years, at a charge of two pence for adults, and a penny for children, when about six thousand persons visited it during the day. These evinced much interest in the various objects displayed for their examination, and their conduct was most exemplary.

There have been seven ordinary meetings of the Society held during the past session:—the first meeting, on the 1st November, 1881, Mr. Robert Young, C.E., in the chair, when an introductory address on the past history and present position of the Society was read by your President, Mr. R. Lloyd Patterson. The second meeting, on the 6th December, 1881, the President in the chair, when Professor Everett read a paper entitled, "Reminiscences of the Paris Electrical Exhibition and Congress." The third meeting, on the 10th January, 1882, the President in the chair, a paper was read by Mr. Joseph John Murphy on "The Rainy or Post-Glacial Period." The fourth meeting, on the 7th February, 1882, the President in the chair, when Professor Letts read a paper on "Diamonds." The fifth meeting, on the 7th March, 1882, the President in the chair, a paper was read by Professor Cunningham on "Corals and Coral Islands." The sixth meeting, on the 4th April, 1882, the President in the chair, a paper was read by Mr. Robert Young, C.E., entitled, "Notes on Bun-a-Mairge Abbey and its surroundings." Mr. Isaac J. Murphy also read a short communication on "A Recent Mechanical Invention by Monsieur Peaucellier." The seventh meeting, on the 25th April, 1882, the President in the chair, a paper was read by the Rev. Robert Workman, of Newtownbreda, entitled, "Forts, Houses, and Churches of Ancient Ireland."

As well as these ordinary meetings, a special meeting was held on the 17th March, 1882, in St. George's Hall, the President, Mr. R. Lloyd Patterson, in the chair, when a lecture was delivered by Mr. Alfred Russell Wallace, F.L.S., F.R.G.S., on "Island Life."

In August last Mr. A. O'D. Taylor, who had acted as Hon. Assistant, Joint or Sole Secretary since the year 1849, a period

of thirty-two years, resigned his office, and shortly afterwards went abroad.

To fill the vacancy thus created, your Council elected Dr. Charles Workman to the Honorary Secretaryship of the Society, and your Council congratulate the Society in having been able to secure the services of a gentleman so eminently qualified in every way as Dr. Workman has proved himself, to discharge the duties pertaining to the office.

It will be seen from the Treasurer's Report that there have been some items of special expenditure during the past year, but against these there have been some unusual sources of income, so that the accounts show a small balance in our favour.

Your Council is sorry to have to report that your Treasurer, Mr. John Anderson, after ably and energetically serving the Society in that office since 1871, a period of eleven years, has signified his desire to retire from the Treasurership.

Your Council now retires from office, and this meeting will be asked to elect fifteen members to form a new Council in its stead. Most of the members of the old Council, being eligible, offer themselves for re election.

R. LLOYD PATTERSON,

14*th June*, 1882. PRESIDENT.

APPENDICES.

I.

Report from the Sub-Committee appointed to Superintend the Curators.

The Natural History Collection.

During the past year Mr. Stewart being principally engaged in arranging and cataloguing the Antiquities, &c., little opportunity occurred of having work done to the Natural History Collections.

The Mammalia in the large case under the gallery of the upper room, were, however, removed from their places, and cleaned, the stands upon which the specimens are mounted were painted, as was also the entire case; several shelves were altered, and the specimens were more fully displayed.

The horns and antlers in the opposite case were removed: many of them were mounted and displayed on the cases and walls of the Lecture-room, the case being afterwards painted for the reception of foreign weapons, &c. The case from which the foreign weapons were removed is now being prepared for the reception of your large collection of exotic shells, at present scattered in different cases and cabinets throughout the building. This collection with others is much in need of arrangement, and we look forward with confidence to Mr. Stewart's scientific knowledge soon shewing itself by a better display of the objects under our care and the rendering them more valuable for educational purposes.

Ethnology.

The foreign dresses, weapons, &c., have been numbered, and all particulars entered in the register; the cases have been painted, and the specimens have been cleaned and re-arranged in the cases under the gallery.

Signed, Joseph Wright.
William Swanston.

Antiquities.

The entire collection has been cleaned, numbered, and registered, *i. e.*, entered in a book with all the information that can be gained concerning them.

The stone implements, including those in the Benn collection, have been catalogued, and the catalogue printed and issued.

Owing to changes which were made in the arrangement of the catalogue, part of this work had to be gone over twice.

Signed, W. H. Patterson.

The Library.

Regarding the Library, I have to report that Mr. Stewart has checked the old catalogue and made all entries of new books up to date, so that a new catalogue may be printed at any time you give me authority to do so. The books have also been arranged in the cases in the new library as far as room was available.

Signed, T. Workman.

II.

DONATIONS TO MUSEUM, SESSION 1881–82.

From A. O'D. Taylor, Esq.

Red Backed Shrike—the first Irish specimen on record.

From W. H. Patterson, Esq., M.R.I.A.

Convolvulus Hawk Moth.

From Samuel Seal, Esq., F.G.S., *per* W. H. Patterson, Esq., M.R.I.A.

Nine Specimens of Fossils, from the coal measures.

From Charles Dundee, Esq., *per* Belfast Naturalists Field Club.

Specimen of Basalt used for square sets, from Ballintoy, Co. Antrim, with chemical analysis.

From A. W. Blackwell, Esq., *per* Belfast Naturalists Field Club.

Stone Grain-rubber, found in pre-historic dwelling at White-park Bay, Ballintoy, 1881.

From Mr. William Millar.

Skull, found at the pre-historic burial place at the "Madman's Window," Glenarm, 1880.

From Seaton F. Milligan, Esq.

Cinerary Urn, broken, found near Omagh.

From John Ward, Esq., F.G.S., *per* Robert Young, Esq., C.E.

Block of Sandstone, from Scrabo Quarries, displaying supposed impressed footprints of an animal.

From Walter Jamieson, Esq.

A piece of Fossilized Wood embedded in bauxite, found near Glenarm.

From The Linen Hall Library.

"Hortus Siccus Britannicus," of James Dickson, F.L.S., consisting of 14 fasciculi of dried plants.

From The British Museum.

A Selection of the British Museum Duplicates, consisting of Insects, Birds, Shells, and Echinodermata, amounting in all to nearly 3,000 specimens.

III.

BOOKS RECEIVED, 1881–82,

From the Institutions whose names are stated below.

Batavia—Naturkundig Ligdschuft Voor Nederlandish, Indie. Deel 40, Achste serie deel 1 1881. *The Society.*

Belfast.—Observations on Aulastoma Heluo. By Robert Templeton, Esq., M.D. *The Author.*

BERLIN.—Gesellschaft für Erdkunde.
Verhandlungen. Vol. 8, parts 4, 5, 6, 7, and 8.
Do. Vol. 9, parts 1, 2, 3, and 4, 1882.
The Society.

BOLOGNA.—Rendiconto dell Accademia delle Scienze, 1880–81.
The Society.

BOSTON.—Science Observer. Vol. 3, parts 33, 34, 35, 36.
The Editor.

BREMEN.—Naturwissenchaftlichen Verein.
Abhandlungen. Bd. 7, heft 1, 2, and 3, 1882.
Do Beilage, No. 8, 1880.
The Society.

BRIGHTON.—Annual Report of Brighton and Sussex Natural History Society, 1881. *The Society.*

BRUSSELS.—Sociétié Entomologique de Belgique.
(Comptes Rendus). Series 3, Nos. 4, 5, 6, 7, 8, 9, 10, 14, 15, and 16, 1881. *The Society.*
Société Royal Malacologique de Belgique.
Tome 10 and 11, 1881-82. *The Society.*
Société Royal de Botanique de Belgique.
Bulletin. Vol. 20, 1881. *The Society.*

CALCUTTA.—Geological Survey of India.
Memoirs. Vol. 6, parts 2 and 3.
Palaeontologica Indica; Fossil Flora of the Gondwanas. Vol. 3, parts 2 and 3.
Index to do. Vols. 1 and 2.
Fossil Flora of the Gondwanas. Supplemental Vol. 3, part 1.
Records. Vol. 13, parts 3 and 4; and Vol. 14, parts 1, 2, 3, 4.
Memoirs. Vol. 18, parts 1, 2, and 3.
Do Palaeontologica. Series 13, vol. 1, part 3.
Do The Fossil Echinoidea. Series 14, 1882.
Do of the Geology of India. Part 3.
The Survey.

CARDIFF.—Naturalists' Society Report and Transactions.
Vol. 12, for 1881, *The Society.*

CASSEL.—Verein für Naturkunde.
Bericht, 1881. *The Society.*

CHERBURG.—Société des Sciences Naturelles et Mathematiques.
Memoirs, 3rd Series, part 2, book 22.
Library Catalogue. *The Society.*

CINCINNATI.—Ohio Mechanics Institute.
Scientific Proceedings. Vol. 1, 1882. *The Institute.*

DANZIG.—Naturforschenden Gesellschaft.
Schriften, New Series, book 15, 1st and 2nd part, 1881. *The Society.*

DUBLIN.—Royal Dublin Society.
Scientific Transactions. Vol. 1, series 2, April and October, 1880-81.
Scientific Proceedings, vol. 2, part 7, 1880; vol. 3, pts. 1 to 4, 1881. *The Society.*

EDINBURGH.—Botanical Society.
Transactions. Vol. 14, part 2, 1882. *The Society.*

ESSEX.—Epping Forest and County of Essex Field Club.
Transactions. Vol. 2, part 4, 1881. *The Club.*

FLORENCE.—Atti della Societa Toscana di Scienze Naturali.
Processi Verbali. Vol. 3, for 1881-82. *The Society.*

GENOA.—Societa di Letture e Conversazioni Scientifiche.
Giornale anno 6. Fasc. 1—4, 1882. *The Society.*

GIESEN.—Oberhessichen Gesellschaft.
Für Natur und Heilkunde. Vol. 20 1881. *The Society.*

GLASGOW.—Natural History Society.
Proceedings. Vol. 4, part 2, 1879–80. *The Society.*
Philosophical Society.
Proceedings. Vol. 13, No. 1, 1880-81. *The Society.*

GLASGOW.—The Gas Question, 1882. James Adams, M.D.
The Author.

GORLITZ.—Naturforschenden Gesellschaft.
Abhandlungen. Vols. 17, 1881. *The Society.*

HAMBURG-ALTONA.—Naturforschenden Gesellschaft.
Verhandlungen, 1880. *The Society.*

HARVARD.—Museum of Comparative Zoology.
Annual Report, 1880-81.
Bulletin. Vol 8.
Bulletin. Vol 6, No. 12, October, 1881; Vol. 9, Nos. 1, 5, June, December, 1881. *The Society.*

HERTFORD.—Hertfordshire Natural History Society and Field Club.
Transactions. Vol. 1, parts 2, 3, 5, and 7, 1880-81.
The Club.

KLAUSENBURG.—Magyar Novenytanclopok.
Parts 4 and 5, 1880-81. *The Society.*

LAUSANNE.—Société Vaudoise.
Bulletin. Vol. 17, Nos. 85 and 86, 1881.
The Society.

LIVERPOOL.—Literary and Philosophical Society.
Proceedings. Vols. 33 and 34 for the Sessions 1878–79, 1879–80. *The Society.*
Split and Other Boulders. by Charles Rickets, M.D., F.G.S., 1881. *The Author.*

LONDON.—Zoological Society.
Proceedings. Parts 1, 2, 3, and 4, 1881.
The Society.
Royal Microscopical Society. Series 2, vol. 1, parts 3, 4, 5, and 6, 1881. Vol. 2, parts 1 and 2.
The Society.
Scientific Roll, "Climate." Parts 1 to 4, 5, 6, 1882.
The Editor.

LONDON.—Royal Astronomical Society.
Memoirs. Vol. 46, 1880, 1881. *The Society.*

MANCHESTER Geological Society.
Vol. 16, parts 10, 1880-81, parts 11, 12, and 13, 1881-82.
The Society.

NEW YORK.—American Geographical Society.
Bulletin. No. 4, 1880. No. 2, 3, and 4, 1881.
Bulletin. No. 6 of vol. 11, 1879. No. 5 of vol. 12. 1880,
Journal. Vols. 11 and 12, 1879-80. *The Society.*

PISA.—Atti della Societa Toscana di Scienze Naturali.
Adunanzia del di. 8 Maggio, 1881. *The Society.*

RIO JANEIRO.—Archives of the National Museum.
Vol. 3, 1878. *The Museum.*

ROME.—Atti della R. Accademia dei Lincei.
Volume 6, Series 1, 2, 3, 4, 5, 6, 7, 8, and 10, 1882.
The Society.

SONDERHAUSEN.—Irmischia. No. 1, 1881 ; No. 65, 1, 2, 3, and 4.
The Editor.

STOCKHOLM.—L'Academie Royale Suedoise des Sciences.
Memoirs. No. 4 to 14.
Atlas of Plates of Seaweed.
Das Gehororgan der Wirbelthere. Part 1. Von Gustaf Retzius.
Bihang Fjeide Bandet. Part 1877.
Bihang Femte Bandet. Part 1878.
Oversight. No. 34, 1877-78 ; No. 35, 1878-79 ; No. 36, 1879-80 ; No. 37, 1880-81.
Lefnadsteckningar. Book 2, part 1, 1878.
The Society.

VIENNA.—K. K. Geologische Reichsanstalt.
Verhandlungen. Nos. 1 to 18, 1881.
Catalog der Austellungs Gegenstande bei der Weiner Weltausstellung, 1873. *The Society.*

WARWICK.—Warwickshire Field Club,
Proceedings, 1881. *The Club.*

WASHINGTON, U.S.A.—Department of Agriculture.
Annual Report, 1878-79.
Memorial of Joseph Henry. *The Department.*
Smithsonian Institute.
Report, 1879.
Contributions to Knowledge, vol. 23.
Miscellaneous Collection, vols. 18 to 21. *The Society.*
Geological Society.
1st Annual Report, 1880. *The Society.*

YOKOHAMA.—Mittheilungen der Deutschen Gesellschaft für Natur und Volkerkunde Ostasiens, 26stes Heft, 1882.
The Society.

PRESIDENTIAL ADDRESS:

AN HISTORICAL SKETCH OF THE SOCIETY,

DELIVERED BY

R. LLOYD PATTERSON, Esq.,

On Tuesday Evening, 1st November, 1881.

On assuming, for the first time at a public meeting, the Presidential Chair of the Belfast Natural History and Philosophical Society, I feel it a primary duty sincerely to thank my fellow-members for having conferred on me the honour of electing me to that position. It were the merest affectation to profess myself otherwise than deeply sensible of the high compliment conveyed in such an appointment. To be successor to those gentlemen who have occupied the chair since the foundation of the society sixty years ago, many of them men of the highest eminence in different branches of science, is a position of which any man, and particularly any business man, may well be proud. Yet I am not so vain as to arrogate the compliment, more than in a very minor degree, to myself; for I feel it is mainly due to the kindly feeling still animating many members of the society towards my father's memory, and to a desire on their part to honour it through me. But it is no affectation to say, as I really feel, how utterly unfit I am for the position. The cares and pressure of business and other engagements, coupled, I suppose, with a want of proper application, have left me in the position of not having cultivated any branch of science. I am therefore quite unable to present you with any-

thing like what an inaugural address should be; and I shall not attempt to imitate the brilliant flights of some of my predecessors in their opening addresses. Fortunately for me, chance comes to my assistance, and, by a coincidence unknown to my fellow members when they elected me, and only lately and quite accidentally noticed by myself, it so happens that this very evening is, to a day, the fiftieth anniversary of the public opening of this Museum, that ceremony having taken place on Tuesday, the 1st of November, 1831. It has therefore occurred to me that an historical sketch of the society and of this building, to myself associated with life-long, interesting, and pleasant recollections, might not be uninteresting to some of our present members who know but little of our earlier history; and I hope that such a sketch may be allowed to pass on this, the occasion of our jubilee, as a substitute for the usual opening address.

This society, then, was founded on 5th June, 1821, when, at a meeting held at the house of Dr. James L. Drummond, he and seven other gentlemen resolved to form themselves into the "Belfast Natural History Society." These seven others, named in the order in which they appear in the society's records, are the following:—William M'Clure, jun., George C. Hyndman, James Grimshaw, jun., Francis Archer, James MacAdam, jun., Robert Patterson, jun., and Robert Simms, jun. The meetings of the society, for more than a year after its foundation, were held at the house of its first president, Dr. Drummond. Recourse was then had to one of the rooms in the adjacent building of the Royal Academical Institution; and another year saw the necessity of still larger accommodation, so that the winter of 1823 finds the society meeting "at their rooms in the Commercial Buildings," where also a collection of objects of natural history, the nucleus of the present Museum, began to be formed. To some the names of a few of the earlier members of the society may be interesting. There joined it in the year of its foundation, 1821, William Tennent, the banker; and in the same year James Emerson, afterwards Sir James Emerson Tennent, a life-long friend and supporter of the so-

ciety, and a most liberal contributor to its collections. Professor Stevelly joined in 1824; William T. Harvey and Surgeon M'Gee in 1825; Robert James Tennent and S. K. Mulholland in 1826; James Bryce and John Thomson in 1827; Dr. MacCormac and Robert S. MacAdam in 1828. The Marquises of Donegall and Downshire became members in 1830; Mr. Grattan in 1831; Dr. Andrews in 1835; and Mr. Gordon Thomson, of whom I may speak as I did of Sir James Emerson Tennent, in 1837. Mr. William Thompson, certainly one of the most distinguished men we ever numbered among our ranks, joined the society in 1825. He was then in his twenty-first year; and it is not long till we find him at his favourite subject, as in 1827 he read a paper on "The Birds of the Copeland Islands."

The society made rapid progress in popularity and membership. Early in 1829, the first mention of any project for a building appears in its records, although, from the way the subject is then mentioned, it is evident it had been under consideration previously. Thus I find on 17th January of that year a resolution was passed declining, with thanks, an offer from "the managers of the Savings Bank respecting the intended building," and further resolved:—"That Dr. Drummond, Mr. Mitchell, Mr. Getty, Mr. Hyndman, and Mr. Patterson be appointed a committee to consider a prospectus to be prepared for opening a subscription towards a building for the purposes of the society." The matter appears again in the minutes of a meeting on 4th February, when mention is made of some negotiations with Mr. Adam M'Clean about a piece of ground in Queen Street. The question crops up again at the next meeting, on 11th February, 1829, when four out of the five gentlemen just named "were appointed to have the prospectus finally arranged," and on 21st February Mr. Getty read a prospectus, which was approved of and ordered to be printed." This prospectus, the subject of so much anxious consideration, was thereupon launched. It bears date 25th February 1829, and to it are appended the names of James L. Drummond, M.D. as president, and George C. Hyndman, as secretary, Dr. Drum-

mond having been re-elected president in 1827, after that office had been held for five years by the Rev. Dr. Hincks. The prospectus is evidently a very carefully prepared composition. Commencing with an account of the origin, aims, and objects of the society, it states that, from the original eight members in 1821, its numbers had then, in 1829, increased to sixty-one; and an appeal is made to the public spirit of the townspeople, to aid in the erection of the projected building, arguing that the benefits conferred by such institutions are two-sided, *i.e.*, to the advantage both of the public and the society. The *Northern Whig* newspaper of the time, then, as ever since, in the forefront of enlightenment and progress, noticed this effort on the part of the young society very favourably. "We have received," it said, "much pleasure from a circular lately issued by the Natural History Society of this town;" and, after giving some extracts from the circular, the *Whig* continued: "After having thus sketched the progress and objects of the society, the circular proceeds in the following truly philosophical manner." Whereupon follow further extracts, the *Whig* concluding as follows:—"Collections of this nature are now (*i.e.* in 1829) to be found in most of the Continental cities, and in the principal towns of the sister kingdoms, and when we consider that Belfast is inferior to none in its liberality and public spirit, we are convinced that no difficulty will be experienced in collecting the funds necessary for so desirable an object." On 13th May "a conversation took place on the subject of the intended building for a Museum," and it was unanimously resolved that five gentlemen named be appointed a committee, with instructions to conclude a bargain for a piece of ground in College Square North for that purpose. Nothing further on the subject appears till 21st October, when we find a record approving of the action of the committee in calling a general meeting of the subscribers for the following day; and at the meeting so held, William Tennent, Esq. was elected treasurer, and a committee of fifteen subscribers was appointed "to determine on a plan, to receive estimates, and take such other measures as may be necessary for the erection of the building."

Matters progressed so that in January 1830, advertisements for estimates for the proposed building appeared in the local papers, Messrs. Duff and Jackson being the architects. The latter gentleman, Mr. Thomas Jackson, is still among us. The foundation stone of the building was laid by the Marquis of Donegall on 4th May, 1830, the *Belfast Commercial Chronicle* of the following day giving an interesting account of the ceremony. After the introductory paragraphs this report proceeds to state that "the foundation stone was then laid by his Lordship with the usual formalities ; the silver trowel employed being the same which his Lordship had used in laying the foundation stone of the Academical Institution, and of a number of our other public buildings. Dr. Drummond, as president of the Natural History Society, then stated that the bottle which was deposited in the first stone contained, among many other things enumerated, 'some verses from the twelfth chapter of Job, in fifteen different lauguages.' William Tennent, Esq., then addressed his Lordship, and expressed, on the part of the Natural History Society, their thanks for his Lordship's attendance on that occasion, and for his uniform attention to the welfare of our various public institutions. The loud acclamations of the concourse of spectators who had assembled to witness the ceremony, evinced the interest they felt in the commencement of a building which, we have no doubt, will be highly creditable to the taste and liberality of our town." The public opening of the Museum took place on Tuesday, 1st November, 1831, and, from the length at which the proceedings are reported in the local papers of the period, it is evident that the event was regarded as one of no small interest and importance. Mr. Edmund Getty, one of the vice-presidents, read the report, which on an occasion of the kind was more than an annual report, and gave a brief history of the society from its foundation, ten years previously, by the eight gentlemen whom I have already named, up to the period under notice. The number of ordinary members at the time of the opening of the Museum had increased to 91, and in addition there were a number of corresponding, visiting, and honorary members, residing in

other parts of the kingdom and in foreign countries. Up to the day of opening, out of a total of about £2,000 required at first, a sum of rather over £1,400 had been raised—a large amount considering the number and means of the inhabitants of the town at the time, and one which speaks well for the liberality and public spirit of our ancestors. The report of the council was followed by an address from the president, Dr. Drummond, who, after expressing his pleasure at the state and prospects of the society, alluded to the acknowledged fact that the pleasure of seeing animals in their natural state is greater than that excited by seeing the same objects preserved in a museum, but rebutted the arguments of those who decry museums on that account, and who say that no one can be a naturalist except those who become so by their own observations, pointing out the advantages that museums afford in bringing before us at one view the animals of the most distant quarters of the world. Referring to the importance of books to the naturalist, he remarked that, although observation is the only way in which new facts can be acquired and existing errors corrected, yet it is by books alone that those facts can be communicated to others. To men of business, whose occupations debar them from opportunities of personal observation, books supply the information they could not otherwise obtain. Next, arguing that every branch of science is useful to every other branch, he urged the propriety of adding a knowledge of natural philosophy, chemistry, &c., to that of natural history, and concluded by expressing a hope, with which, after the lapse of fifty years, I entirely sympathise, that an occasional exhibition of the fine arts might be held in the large upper room of the Museum. A Dublin journal of the period concluded a flattering notice of the society and the Museum as follows :—" The Belfast Museum is the first ever erected in Ireland by voluntary subscription, and it has our warmest wishes for its success. We have marked the progress of the society to which it owes its origin with deep admiration, and we have sincere pleasure in placing it before the public as an example worthy of imitation, and deserving of national applause."

At a public meeting of the society, held on 19th September, 1833, a statement of the total receipts and expenditure to date was submitted. From that it appeared that the total cost of the building and of furnishing the parts then in use amounted to £2,321 9s. 8d., and the receipts were £1,594 8s. 6d., leaving a balance due of £727 1s. 2d. A new financial scheme was proposed with a view of liquidating this debt, and this scheme was so successful that by October it was announced that, through the continued exertions of some members of the society, the Museum was then absolutely free from debt.

Up to, and for some time after the year 1836 the large upper room of the building continued unfurnished, but not entirely unused, as during the period from 1836 to 1843, I find mention of several exhibitions of paintings being held in it. The following paragraph is from the annual report presented in May, 1838 :—" 'The Belfast Association of Artists,' having applied this session again for permission to hold another exhibition of paintings in the Museum, the council agreed to their request, and a large collection of paintings and statuary was accordingly exhibited for six weeks. . . . The success of these exhibitions has led to a proposal for erecting in Belfast a building devoted entirely to the fine arts." I observe that in 1842 the "Northern Art Union" were having an exhibition of paintings in the Museum, and a "fashionable promenade," with a regimental band in attendance, was advertised to take place on 1st and 3rd December. In August, 1843, another exhibition of paintings, this time got up by the "Belfast Fine Arts Society," was opened in the Museum. Here within seven years there appears to have been three bodies or associations holding art exhibitions in our building. Meantime the meetings of the society had become so popular and largely attended that the accommodation in the ordinary lecture-room was inadequate, and more space was wanted for the proper display of the constantly increasing collections. It was therefore proposed (in 1838) "to erect in the rear of the Belfast Museum a spacious lecture-room, with a laboratory and an apparatus-room attached." The estimated cost of this projected building was £800, towards

which, by February, 1839, £300 had been subscribed. Subscriptions seem, however, to have come in but slowly, for in February, 1840, some reductions of expense in the erection of the projected new building were discussed. The following month sees the scheme again before the public, a circular respecting it, and bearing the names of three prominent members of the society, having been issued. The project seemed after this to lie in abeyance for several years, till March, 1844, when it was revived, and another circular on the subject appears in February, 1845; but at the annual meeting held on 13th May, 1846, the report stated that the views of the council had been modified by circumstances, and the council recommended instead that the large upper room be fitted up for the reception of cases and specimens. The report submitted to the annual meeting in 1847 stated that, owing to the "distressing calamities" under which the country was suffering, no progress had been made; and it was not till 1850 (although frequent allusions to the subject appear in the interim) that the fitting of the upper room was definitely decided on, and ordered to be completed before the next session opened. This was done; and accordingly in that year, 1850, the upper room was fitted up in the manner in which, with some minor changes, you still see it.

The idea of inviting the British Association for the Advancement of Science to hold its annual meeting in Belfast, which it did in 1852, was first publicly mooted at a conversazione held in the Museum on 16th January, 1849, and the invitation was given at the meeting of the association in Birmingham that year.

Nothing of special moment occurred in the society till 1852, when, at the close of a meeting held on 18th February, it was announced that "Mr. Patterson had just received a letter from London," communicating the melancholy intelligence of the death there of Wm. Thompson, Esq., the president of the society, on the morning of the previous day, the 17th. The death of this eminent naturalist and accomplished gentleman in the prime of life, his 47th year, inflicted an almost irreparable loss on the society, of which he was such a distinguished orna-

ment. Many of his fellow-members were equally earnest ; indeed it was hardly possible to come much into contact with him without sharing his enthusiasm ; but of his colleagues on the council at the time there was not one who had not either business or professional engagements that had a first claim on their time and thoughts ; Mr. Thompson himself being the only member of the council possessing ample private means and complete leisure. Both he placed freely at the disposal of his fellow-members, and he formed a most useful connecting link between the then still comparatively young provincial society and the older and larger metropolitan societies, of England and Scotland, as well as of this country. Our society lost no time in taking steps to mark their sense of the loss they had sustained in Mr. Thompson's removal, and of their determination to perpetuate his memory. The erection of the "Thompson room," to contain the collections bequeathed by him to the Museum, was almost at once determined on and proceeded with, the appeal of the council to the public for funds being so promptly and liberally responded to that the room was completed by the autumn of that same year—1852—when the meeting of the British Association was an event of considerable importance to us, giving a stimulus to scientific pursuits, and imparting a prestige to the society that continued for long after.

The gentlemen who have held the office of president after Mr. Thompson' decease were Mr. Patterson, from 1852 to 54, and on three subsequent occasions ; Dr. Andrews, from 1854 to 56 ; Dr. Stevelly, from 1856 to 58; Mr. Hyndman, from 1858 to 60; Mr. James MacAdam, from 1860 to 61, but he died a few days after his re-election in the latter year. Dr., now Sir C., Wyville Thomson was our president from 1862 to 64, and again later ; Professor James Thomson, from 1864 to 66 ; Mr. Joseph John Murphy, from 1866 to 68, and again from 1871 to 75. Mr. Murphy may now be regarded as one of our older, and he certainly always has been one of our most learned, useful, and energetic members. We have also had Dr. Hodges ; and since then Mr. Robert Young, than whom we have had no superior in any time ; Professor Purser ; and, finally, the individual who now has the

honour of addressing you. I hope I have not overlooked mentioning anyone ; and, assuming my enumeration is correct, it makes fifteen presidents in the sixty years of the society's existence.

I omitted mentioning in its proper place that very many years ago, I think it was in 1840, the society changed its name from its original appellation of the Belfast Natural History Society to the more comprehensive title which it still bears, and at the same time enlarged the scope of its operations in the direction indicated by this change. During the past five or six-and-twenty years the society has experienced some vicissitudes of fortune. About the time of the erection of the Thompson room, the funds for which were easily obtained, a debt of about £300 due by the society began to be increased by additional expenses being incurred without any concurrent increase of income, so that by June, 1855, the debts of the society had increased to £500 of borrowed money and £168 due for accounts, a total indebtedness of £668. The council then became thoroughly alive to the necessity of grappling vigorously with the evil of this increasing debt. In November and December, 1855, Mr. Patterson delivered a course of lectures, an example followed in subsequent years by Mr. Richard Davison, M.P., and Mr. Hyndman, by Dr. Andrews, Mr. James MacAdam, and Dr. Wyville Thomson, all of which resulted in substantial benefit to the society. Continued efforts of this kind, and obtaining new shareholders and subscribers, ultimately had the desired result, and the annual report presented to the shareholders of the Museum in May, 1866, contained the satisfactory announcement that the institution was at that time perfectly free of debt. So it has almost ever since remained ; but I regret to add that increased expenditure, without any additional income, begins again, the last year or two, to put our balances on the wrong side ; and without additional income it will not be possible for the council to continue certain new arrangements entered into during last session, with the intention of increasing the usefulness and attractiveness of the Museum, and its varied and valuable collections, which are being constantly added to, the last addition of much impor-

tance being the collection of Irish antiquities presented last year by Mr. Benn, and now deposited in the new room downstairs.

An important, but now by many almost forgotten, episode in the history of the society was what is spoken of in our records as "the Porter bequest." This was a sum of £5,000, apparently intended to be willed to the Museum by the late Mr. John Porter of this town. The validity of this bequest was called in question; and, after getting the best legal opinions obtainable on the subject, the council of the society considered that it would not be prudent to enter into litigation to support their claim. They therefore abandoned it, and, having informed the residuary legatee of their intention of doing so, this gentleman offered, on 10th May, 1868—(1) To provide cases for the proper display of the articles presented to the Museum by Mr. Porter, (2) to pay the law costs incurred; and (3) to present the Museum with a sum of £500, which offers were duly accepted. The gentleman who acted thus handsomely is my friend Mr. Edward Porter Cowan,* the present excellent and popular Mayor of Belfast.

In a brief sketch such as this of the history of the society and the Museum it is not easy to adhere strictly to the chronological order of events without increasing the tedium of the description. However, I think that, except the addition to the building, which was completed only last year, and which is so recent that it need not now be alluded to, I have mentioned the principal events in the material history if this Museum; but the moral history of the society that meets within its walls would not be so easily written. That the society has exercised a considerable influence towards the cultivation of natural science in the town and district is undeniable, and the future historian of Belfast will fail in his duty if he do not accord to many of those whose names have been mentioned here this evening the acknowledgments that are due in this regard. I feel, however, and say it with regret, that in my opinion, the society has perhaps passed the zenith of its importance; and that its influence and the interest excited by its proceediugs have latterly been on the

* Now Sir Edward Porter Cowan.

wane ; but let us hope not permanently so. For this waning interest there are many reasons, most of them arising from circumstances beyond our control. Some of these I shall eudeavour to point out. Firstly, this society has now to meet not only the competing attractions of the young and vigorous Naturalists' Field Club, of which my friend Mr. Robert Young is this year the excellent president (a matter of congratulation both for the club and himself), but also those of the societies connected with places of worship in town, the young men of these congregations associating themselves with the societies connected with those churches of which they are members. Thus there is material enough to make one large flourishing society, so scattered that its energy, powerful for greater results if united, is in some degree weakened in consequence of its subdivision. Again, sixty years ago, when the society was founded, the population of Belfast did not number more than 33,000, compared with 207,000, at the present time. But then the people, professional men, merchauts, traders, and others, all resided in the town, while now the large majority of these classes reside either in the country or in suburbs sufficiently distant to make it inconvenient for them to return after having left it at the close of their business day. Even the last twenty or thirty years have made a further great change in this respect. It is quite in my recollection when most of the leading members of the society resided almost within call. Now only one member of the council resides near us ; the rest are so scattered that it has become almost impossible for the council to hold their meetings for the transaction of the society's business at each other's houses, as was long their pleasant and social practice. Another and no less powerful factor in the gradual decadence of such societies is the recent enormous increase in the variety and circulation of newspapers, reviews, and periodicals of all kinds. Most of these are general, but many special, so much so that there is hardly a leading science, and there certainly is no important trade or industry, in the sister kingdom without its exponent and reflex in the press. What the *Economist* is to the banker or merchant ; the *Engineer*, the *Grocer*, or the *Builder* to those

indicated by these names ; the *Railway Times* to the director ; the *Field* to the sportsman ; or the *Era* to the actor, is the *Art Journal* to the sculptor or painter, the *Lancet* to the physician, the *Ibis* to the lover of birds, or the *Zoologist* to its namesake in the flesh. The spirit of the age sympathises with this modern luxury of different readers indulging their particular tastes at their own fireside, while it is further stimulated by the freer circulation of money as well as by the cheapness of some and the excellence of many of the periodicals in question. When it is borne in mind that the pages of some of the best modern reviews are open to men of mark in politics, religion, literature, art and science, and that the reader can thus have easy access to the contemporary thoughts of the best men of the day, in whatever direction he may choose to seek for mental recreation or relaxation, it ceases to be a matter of surprise, not only that the meetings of a society such as ours no longer possess their old charm of attracting large audiences, but that public lectures generally have ceased to be regarded as the most popular means of imparting instruction by a large majority of those for whose benefit they were intended. They no longer attract the audiences ; are voted "slow ;" and are consequently neglected for some other more attractive and amusing, even if less improving, ways of spending time, these remarks applying to other large towns as well as to our own. In confirmation of this I may mention having lately noticed an announcement of the closing of the Polytechnic Institution—long one of the most popular places of public resort in London. Here were delivered popular lectures upon scientific or semi-scientific subjects, often illustrated by attractive experiments. The Polytechnic did good work in its time : but for some years back its audiences have been declining, its work seemed to be done, and having attained to a mature old age, it lately died a natural death. Another cause, also leading in the direction we have been considering, lies in the greatly increased modern facilities for travel. But perhaps the most powerful factor of all is to be found in the greater pressure under which most of us live nowadays. The style of living among people in the same position is more expensive than

it was. Houses, equipages, dress, and entertainments are all more costly ; the working hours are shorter, while the holidays are longer ; and yet withal competition in most businesses is keener, and the struggle in what Bret Harte has so aptly described as " the fierce race for wealth " more severe than ever. Hence it comes that the exeitement of our days seems to demand a reflex of excitement in our evenings ; the quieter pursuits of former times no longer suffice for the youth of the present day, and I fear we cannot deny that the literary, scientific, and artistic character of the town has not kept pace with its rapid growth in population and wealth. The age we live in seems to be becoming more and more utilitarian ; we are forced to admit this, and having to meet facts as they are, not perhaps as we might wish them to be , it behoves us to pause and consider whether, as we cannot lead as we might like, we might not lead in the direction where we may be of most use. Whether, in fact, we cannot use our organization here, partially at least, for the furtherance of such useful objects as the material, as well as the moral and intellectual, advancement of the community ; and I believe we can aid towards the attainment of so desirable an end by encouraging communications here dealing with the application of science to, and combining of it with the practical aims and objects of daily life.

Economic geology, for instance, teaches us how best to utilize such deposits as the coal measures of Tyrone, the salt beds at Carrickfergus, and the hematite iron ore fields of Antrim. Engineering and applied mechanics serve not only to economise the use and the wear and tear of, but even to raise the value of, manual labour. The earnings of, say, mechanics or harvest labourers, or indeed of any class of workmen, have not been reduced in consequence of the invention of indoor labour-saving appliances or of reaping or mowing machines, but are higher now than formerly, while females can earn much better wages in a mill or factory or in many other ways than they formerly did while at the needle or with the spinning wheel. The discoveries in magnetism and electricity are truly marvellous, and their results are no less so. All the countries of the civilised

world are now united by materially slender, but morally powerful bonds, enabling persons in different hemispheres to converse with one another across continents and through oceans. The merchant in London can in a day buy a cargo of rice or cotton in India, or tea in China; and, on the same day, can arrange for the immediate payment of his purchase by a remittance of silver direct from San Francisco. Important transactions now are often done so closely that, in an operation of this nature, sometimes involving delicate and intricate calculations in cross-exchanges, the cost and time involved in remitting hard money from this country would often be sufficient to render the business unprofitable, if not impossible. Speaking the other day at Birmingham, the eminent electrician, Dr. Siemens, said that "that form of energy known as the electric current was nothing more than the philosopher's delight forty years ago;" and long since that period it continued to be regarded as an unmanageable element. Now it has been rendered tractable, forced to admit the superiority of its master, and even submitting to be stored and carried about for use when and where required. The importance of these discoveries is only now being brought home to some of us in the electric light and the telephone. One of the spinning mills in town is now being lit by electricity: and most of the arrangements for this meeting were made by our hon. secretary, Dr. Workman, and myself conversing freely by means of the telephone between his house in Balmoral Terrace and my office in Corporation Street, far asunder at quite different ends of the town. The high authority just named (Dr. Siemens) considers electricity destined to supply both the light and much of the power of the future.

I suppose there is no science, the pursuit of which and its application to practical objects, has done more for the benefit of mankind than chemistry. It has added to the productive power of the soil, and thus aided agriculture by ascertaining, pointing out, and supplying the constituents most wanted for the production of any particular crop; by the manufacture of phosphates, and in the utilisation of sewage, all of which tend, by increasing the supplies, to reduce the prices of food for the

masses. This, the agricultural branch of chemical science, has an able exponent in our fellow-member, one of my predecessors in this chair, Dr. Hodges. There is scarcely an important industry that has not felt the influence of chemistry ; it is brought perhaps most home to ourselves by the assistance it renders in the bleaching and dyeing of yarns and threads, linens, and other fabrics ; while in the detection of adulteration of food, impurities in water, or poisonous substances in the human frame, it comes to the assistance of the social reformer, the physician, and the jurist. This society derives lustre from the fact that it reckons among its now oldest members, and as a past president, one of the most renowned of living chemists, Dr. Andrews. Again, some branches of what is popularly known as social science, such, for instance, as sanitary reform, and education, particularly technical education, to which I purpose reverting later, would not be out of place here ; and the somewhat neglected study of one branch of zoology, I mean the natural history of fishes, might be attended to with great advantage, with the view, by the increased knowledge it would afford, to aid in the development of the undoubtedly very valuable, but only partially worked Irish fisheries. Although claiming as yet no place among the exact sciences, it must be admitted that meteorology is progressing. Within our recollection weather forecasts were regarded as little better than mere speculations, but now, that formerly mythical personage, the clerk of the weather, has both "a local habitation and a name," and the weather forecasts that daily issue from his office, although of course sometimes at fault, are so generally accurate that their value to the seafaring classes, and especially to fishermen, will not be disputed. In this connection, I think it only right to pay a tribute to the courage and devotion of Mr. Clement L. Wragge, F.R.G.S., a gentleman who has been lately carrying out a series of meteorological observations on Ben Nevis, and who, at the imminent risk of his life, ascended the mountain in the fearful storm of last Friday fortnight, the 14th October, for the purpose of taking some observations, from which his knowledge and experience enable him to draw some valuable deductions as

to the operation of those hitherto hidden laws that govern the course of storms. I might multiply examples, but these indications as to the direction in which I think we might endeavour to influence discussions here, advocating the application of scientific discovery to practical aims, may suffice for the present, and I therefore pass on to another branch of my subject.

It is generally admitted that the United Kingdom has long enjoyed a position of industrial and commercial supremacy over the rest of the world. That position she still maintains, but no longer so far ahead of some of her competitors as formerly; and it may not be unprofitable to inquire what first led to this supremacy, and why it is now threatened. On both these points, especially on the latter, differences of opinion prevail, but I believe what mainly led to it was the partly natural and partly acquired aptitude of the people to adapt themselves to circumstances, and their ability to take full advantage of the enormous mineral wealth with which the country had been so richly endowed by nature. The people, too, had plenty of working enterprise and energy, but along with this they possessed the characteristic of seeing quickly, almost by intuition, when their work ceased to be fairly reproductive, and when it was time for them to turn and change. Then there arose from time to time men of exceptional reflective, inventive and mechanical talent, whose names will be remembered as long as British science and British commerce endure; men like Watt and Arkwright and the two Stephensons, like Davy and Faraday and many others; men, I say, like these arose often to have to combat prejudices and meet opposition, but finally to conquer, and to find an army of workers ready to follow their lead and to devote their own energy to the development of our resources. Again, these countries have produced men of the most profound genius in every walk of life—authors, poets, statesmen, soldiers and sailors, historians, philosophers, artists, and scientists in all branches. It is only with some of these latter that we have now specially to deal, although all the rest, and many others too numerous to mention, have not been without much influence in moulding the national character, a pro-

minent feature in which, with, I regret to say, some foul exceptions, has ever been a love of "fair play." This latter led to an early development of our liberties, and this again to England long having been the refuge for the persecuted and the exiles of other countries. It is too much a matter of history to require further mention here how some new industries were introduced and other older ones improved by some of these refugees. It is in such ways and by such combinations of circumstances as those now briefly indicated that our national industrial character has been formed, and that character, coupled with our insular position, our mineral wealth, and other natural advantages, is what, in my opinion, has led to our commercial supremacy. Having attained to a certain position, it is the duty of every individual in the community to do what he can to maintain it. Is then our position threatened or assailed? If so, by whom, and how are we to meet and to defeat the attack? In the first place, I do not consider that it is so seriously threatened as some make out; but, granted that it is threatened to some extent, how comes it? I believe it arises from different causes in the different articles in which foreign competition presses on us most severely. In some things, such, for instance, as linen yarns and plain articles generally, the cause seems to be found in the longer hours and lower wages that prevail in the establishments of our Continental rivals. We cannot expect, nor indeed do we wish for, any retrogressive legislation with regard to hours of labour; so, I fear, unless we can further lower the cost of production, we must let those rivals keep what they have got, consoling ourselves with the reflection that what they have got is what was least worth our while to keep. In other articles, however, it is superior taste, and in others, again, superior skill and the applied results of a carefully nurtured system of technical instruction, that are causing us to feel foreign competition as we do. The advocacy of scientific and technical education comes so legitimately within the scope of our operations that I proceed to allude briefly to the subject; doing so, indeed, requires no apology, as it is one of the questions of the day. It was lately brought so fully before

the local public in a very able letter addressed by my friend, Mr. Loewenthal, the President of the Linen Merchants' Association, to that body, and shortly thereafter brought by deputation from that body before the Chamber of Commerce, that I need not now refer to it at any great length. The importance of the subject has long been recognised in several Continental countries; the result being that in chemistry, and in the arts as applied to decorative furniture and architecture, room-papers, curtain and other fabrics, whether with designs woven into or printed on them, and to other articles, we are simply beaten. The manufacturing towns in England and Scotland are now fully alive to the importance of not allowing themselves to get further behind; and, in most cases, without waiting for Government aid, the want has been supplied either by private liberality, as in the case of the Mason College at Birmingham and the intended Baxter College at Dundee, or by public subscription, as in the case of the Yorkshire College at Leeds. The large cities and towns of Glasgow, Bradford, Huddersfield, and others have schools which make weaving and designing a speciality; while Sheffield has one more devoted to its particular industries, such as metallurgy, &c. Four months ago a new university college was opened at Nottingham, part of the aim of which is the teaching of technology. The instructions in this department (as I learn from Mr. Loewenthal's letter) will embrace the manufacture of cloth, cotton, silk, lace and hosiery, bleaching, dyeing and printing, mechanics, chemistry, light, heat, steam, electricity and magnetism, machine drawing, principles of mining, and almost as many more subjects, which I do not wish to occupy more of your time in enumerating. I have to thank my friend, Mr. John Marshall, of Leeds, for kindly sending me a copy of the seventh annual report of the Yorkshire College (June, 1881); and from this I see that among many general subjects, the following are prominent:—Experimental physics, chemistry, geology and mining, and, separately, coal mining, and civil and mechanical engineering. As might be expected in Leeds, the capital of the immense woollen manufacturing industry of Yorkshire, the textile industries and dyeing departments receive

special attention. The separate report on these is a very interesting document; the weaving department had 78 and the dyeing department 58 students. The second year students made several of the coal-tar colours, starting with benzol, a most important matter, to which I purpose reverting later. Including a sum of £15,000 donation (besides an endowment of £1,250 a year) from the Clothworkers' Company of London, the public subscriptions to the general and building funds of the Yorkshire College, at the time the report alluded to was issued last summer, amounted to over £82,000! Besides the varied technical instruction given at Anderson's College, Glasgow (for the calendar of which for the present session I am indebted to Mr. James Barnett), and which includes, with special prominence, applied mechanics and chemistry, the city of Glasgow has lately established its separate technical college; but up to the present the weaving branch is, I believe, the only one that has got started. The syllabus for the present session, which I have received, shows that full practical instruction on the looms themselves, and in a great variety of fabrics, is here given. It is satisfactory to know that the authorities of Queen's College here are alive to the necessity of keeping abreast of the times in the proper teaching of those branches of science to which I have been specially alluding. The accommodation and appliances that were sufficient over thirty years ago for giving instruction in natural philosophy and chemistry are now, with the changes that have occurred within this period, no longer adequate; and it is the intention of the college authorities, supported by the Corporation, the Chamber of Commerce, and the borough members, to apply to Government for a grant of some £10,000 to provide the additional accommodation and apparatus required. On behalf of this, the oldest scientific society in Belfast, I purpose also supporting the application. In illustration of the want being actually felt, a friend of mine who was commencing a certain kind of chemical business here had to get a practical chemist as manager of his works from England.

In connection with a local bleaching and printing company,

of which I have the honour to be chairman, I lately learned some things that surprised me. When speaking just now of the Yorkshire College, I alluded to a circumstance mentioned in the report that some of the students there had made several of the coal tar colours from benzol. That statement does not convey much significance to the uninitiated without explanation. Benzol itself, as I understand, is an extract from common coal tar. What are known in the trade as the aniline colours were the first dyes produced from coal tar ; but it was found by experience that while these suited very well for silk or woollen fabrics, as they became fast without a mordant, they did not answer for goods made from hard fibres, like flax and hemp. The first aniline colour of commerce was mauve. This was an entirely new colour ; and I well remember the sensation that its appearance created three or four-and-twenty years ago. A German chemist, Hoffman, then brought out other colours, rosaniline, magenta, &c. Another extract from benzol is anthracine, and from it are derived all the so-called alizarine colours. The colour basis of alizarine is scarlet : it is largely taking the place of madder, which was hitherto the principal red dye, yielding derivatives of purples and down to chocolate colours. From the alizarine scarlet as a basis the derivatives of purples, lilacs, &c., can also be obtained. A German chemical company have lately brought out an alizarine blue which seems likely to supplant indigo, the latter being not only more expensive, but also more difficult to work. Again, we have alizarine orange, and a variety of graduated shades derived from it, down to brown. Other products from the same original base—coal tar—are ceruline, which produces a green, and mytheline green, from which also a blue can be derived. I shall go no further into details, but the examples given will suffice to show the variety and perfection of these new colours, and the reason I mention the matter at all is partly to illustrate the progress of chemical research in this particular direction, and its use to commerce, and partly to state that these colours, used so largely in our dye and print works, are all made in Germany. We in our gasworks make the coal tar from which

the anthracine is derived. The Germans import the anthracine from us, make these beautiful colours from it, and sell them back to us. We can bleach and print better than the Germans, and the finish we put upon our goods is unrivalled; but so much are we at their mercy for these colours that by a trade combination they lately advanced their prices for some of them fifty per cent.; and we are at present, and I suppose, till we make the colours for ourselves shall continue, powerless to resist. Where can we find a stronger argument than this in favour of technical education?

It is, however, not alone in manufacturing, but also in purely mercantile pursuits, that technical instruction is given on the Continent. I lately read in the *Economist* that a superior school of commercial studies, created by the Paris Chamber of Commerce, will be opened on the 3rd November. The Chamber possesses already two schools of commerce; the new one, for which a spacious building has been erected, is intended to complete the studies of the pupils in the highest branches of commercial, industrial, and financial knowledge, in order to qualify them for the direction of banks, manufactories, or public companies, or for consular posts. The teaching staff consists of thirty professors. Among the other subjects comprised in the programme are monetary systems, cheques, insurance, maritime law, bourse operations, minerals and mines, yarns, tissues, and dyes, patent laws, analyses, adulterations, &c.

We want, however, more than all that. While the school of art is doing excellent work in its way, and work too that cannot fail to be beneficial to the artistic departments of our business, we want besides a permanent art gallery, which should be supplemented by periodical loan and sale exhibitions. Access to the beautiful in art, and education by the eye, cannot fail to aid in elevating the public taste and tone; yet for any art exhibitions worthy the name this large town has for several years been indebted to the enterprise of a private firm, Messrs. Rodman, to whom I heartily wish every success in their spirited undertaking. Although a majority of our municipal authorities thought otherwise, I consider that we do want a free public library

too. Other towns of inferior size in England and Scotland have their libraries, which are largely used, and evidently highly appreciated, by the classes for whom they are intended. Leeds, for instance, a town not much superior in size to Belfast, had in its library at the date of the last report to which I had access, over 20,000 volumes in its reference department, and over 50,000 in its lending department. Four years ago, Dundee, a smaller town than Belfast, had nearly 30,000 volumes in the two departments. These have been established under the Public Libraries Acts, which some gentlemen not long since sought to have applied to Belfast.

I shall not detain you much longer ; but there is one other matter that I wish briefly to advert to. It will hardly be credited that our society's membership now is virtually no larger than it was when the Museum was built fifty years ago, and when the population of the town was less than one-fourth of what it now is. I do not expect to keep up the old proportion of membership to population ; but I regard with disappointment the apathy of the public, and with more than disappointment the not unfrequently expressed wish to put a commercial value on membership here in return for the annual subscription. We cannot offer a direct return in money, and it is very discouraging when one is trying to enlist new members to be met with such selfish remarks as "It does me no good," or "I get nothing for my money." If the Museum and the society are, as I think they are, deserving of public support, they should get it more freely and ungrudgingly than they do. Fifty or sixty more members at an annual subscription of only a guinea each would make us financially easy, but still with no margin for incidental expenses, painting or repairs of buildings, &c. It would seem strange if, in such a large community, such a comparatively small number could not be had notwithstanding all the counter attractions alluded to. However, I feel strongly that, as the Museum exists for the public, and not the public for the Museum, if the public won't support it, it will have to go down, for I do not see the object of keeping it in being by spasmodic efforts, from any mere sentimental or conservative

feeling. I confess I have been thinking that some parts of our collection—such for instance as the quadrupeds—are so incomplete as to be of little value; and the necessity for these no longer exists to the same extent as formerly, as there is now, I understand, a more complete collection of such at the Queen's College. I speak only for myself, and am not to be understood as making any proposal, as I have not mentioned the subject to my colleagues, who may entirely dissent from me; but, for my own part, I should not object to see the Museum handed over as a present to the town, as the nucleus for a Free Museum and Library. We have fine collections in ornithology, geology, Irish antiquities, foreign arms and implements, and other things; but in those departments where our collections are poor and not progressive they might, with little disadvantage, be dropped, and the space thus gained be devoted to books. There is room enough at the rere for another pretty large building, part of which might be arranged as an art gallery, and the remainder to library purposes. I apologise to my fellow-members for having said so much without first speaking to them; but they may rest satisfied that I have not compromised them or the society in any way, and what has been said may bear fruit in one direction or the other. While I should much regret to see the Museum terminate its independent existence, I should regret still more to see that existence indefinitely prolonged if the building could otherwise be devoted to more distinctly useful purposes. Such a step as the giving up the ownership and management of the Museum would by no means entail the extinction of the society, which would go on, as I hope it will in any case, prosperously and vigorously.

A great English statesman, who is a true friend of this country, alluded with regret in one of his recent public utterances to the absence of a middle class in Ireland. Such is unfortunately the case in the greater part of the country; but I claim for this town and most of the province the possession of a middle class—not so rich, truly, as the similar class in the sister island, but not inferior to them in those qualities that go to make a country prosperous and contented—I mean intelligence, indus-

try, and thrift. I have no doubt most of the proprietors of this Museum, belonging, as they do, to the intelligent class referred to, would consider the question of parting with their property, if it came to that, in no narrow spirit, but with a primary view of enlarging the sphere of usefulness of the museum, through increased opportunities of giving instruction and imparting knowledge to a wider circle than that of the society alone. With that view, and in that spirit, I submit these concluding sentences to the consideration of my fellow-members, and I thank you all very sincerely for the patient hearing you have accorded me.

6th December, 1881.

The President, R. L. Patterson, Esq., in the Chair.

A paper was read by Professor Everett, on

REMINISCENCES OF THE PARIS ELECTRICAL EXHIBITION AND CONGRESS.

My first visit to the Exhibition was on Monday morning, August 12, 1881, and on entering it I went at once to the British Office to report myself. Lord Crawford, the Chief British Commissioner, was there, with Professor Hughes, the inventor of the printing telegraph and of the microphone, whose acquaintance I had made in London two years before, on the occasion of a visit which we both paid, by invitation, to the Laboratory of Mr. Warren De La Rue, where we witnessed the performances of Mr. De La Rue's battery of 5000 chloride of silver cells, and saw the marvellously beautiful discharges in his monster vacuum tubes. I received from these gentlemen a warm welcome, combined with the information that on receiving my letter of acceptance they had written to ask me to serve as one of the ten British Jurors of the Exhibition, which letter, however, having been addressed to Belfast, had not yet reached me. The jury were to begin work on the 20th September, and continue three or four weeks. After taking a little time to consider the matter as I walked over the Exhibition, I came to the conclusion that I ought to make the most of such a splendid opportunity of seeing what was doing in the electrical world. The Congress was not to meet till Thursday, so I had Monday, Tuesday and Wednesday free to roam about in the Exhibition at my own sweet will.

The building itself, the well-known Palais d'Industrie in the Champs Elysées, is a Crystal Palace, and was built for the first French Exhibition of the Industry of all Nations. It is not near so large as the Sydenham Crystal Palace, but is perhaps 200 yards long and 80 broad—a very good size for an Exhibition, as it is big enough to hold all that one can see in reasonable time, and is not so large as to fatigue one with the mere physical labour of walking over it.

The interior presented a bright and animated appearance, even in the daytime, when there were not many electric lights to be seen, and was still more striking with the blaze of the lamps at night. It was tastefully decorated. The ground floor was parcelled out among the different nations, and could all be surveyed at a glance by a spectator in the gallery. There were electric lamps, dynamo machines, telephones, telegraphs of every form, some of them printing messages by putting down keys like the keys of a piano, some of them producing copies of pictures which were gradually built up line by line like a piece of Berlin wool work. There were sewing machines and weaving machines driven by electricity, and two great pumps pouring fourth immense sheets of a bright red liquid in a manner calculated to attract the attention of all beholders, also driven by electricity. There were baths with spoons and other articles suspended in them, undergoing the processes of electro-plating and gilding ; and large plates of pure copper, larger and thicker than any of the flagstones of our pavements, which had been deposited by the electro-metallurgical machine of Siemens. There were the newest and best forms of friction machines, and improvements on the Holtz, which render it independent of frictional aid at starting. There was the gigantic Ruhmkorff coil about six feet long, made for Mr. Spottiswoode, by Apps ; a specimen of Sir Wm. Thomson's Siphon Recorder, as well as of his large Absolute Electrometer ; cable-laying apparatus, and a beautiful model of Messrs. Siemens' cable-laying steamer, the "Faraday." There was the Phonograph, and the still newer invention, the Photophone ; while among antiquities there were gigantic electrical machines and Leyden jars

belonging to the early days of electrical invention in Holland, apparatus belonging to Volta, an autograph of Galvani, Wheatstone's revolving mirror for measuring the velocity of electricity, and Faraday's iron ring with two coils of wire wound on it, by the aid of which he made his first observation of induced currents.

Outside the Exhibition there was the Electric Tramcar, conveying passengers over a tramway a quarter of a mile long, from the Place de la Concorde to the Exhibition, and driven by an invisible influence conducted to it by means of two travelling wires, which had one end fastened to the car, while the other end travelled along a light rail suspended on posts beside the line. These two wires, it is to be remarked, did not drag the car, but were visibly dragged by it, a circumstance which brought home forcibly to one's mind the mysterious character of the unseen propelling agent. The current conveyed by these wires passed through an electromotor beneath the floor of the car, causing its armature to rotate and drive the wheels. The current itself was produced by a dynamo machine in the centre of the exhibition building, and this machine was almost precisely similar to the electromotor ; for it is a general property of a large class of electro-magnetic machines that they can either be used for furnishing a current, or can themselves be driven by a current supplied to them from without.

The Exhibition was open to the public from 10 a.m. to 6 p.m., and then after being closed for two hours was open again from 8 to 11. The evening was the time when it was most crowded, and on three evenings in the week there was an extra crowd in one of the galleries, where some hundreds of people were standing in queues waiting their turn to be admitted to one of four rooms which were inscribed with the words, "Telephone de l'Opera." In each of these rooms there were twenty pairs of telephones hung on panels round the walls and having flexible wire cords attached to them, which were in communication with the Opera House, some two miles distant. On putting one of these pairs of telephones to your ears you distinctly heard the music that was being performed at the Opera;

and after hearing it for three minutes your party had to leave and make way for another detachment. One gentleman of my acquaintance heard the voice of a soprano singer with such deafening loudness that he had to remove the telephone from his ear. In taking my three minute turn I did not hear anything so loud as this, but I heard each singer well, some of them louder than others ; and what struck me most was that some of them seemed to be singing into my right ear and some into my left. The cause of this I afterwards learned, and it was just what I at first surmised. The telephone at my right was connected with a transmitter in the right hand part of the stage, and the telephone at my left ear with one in the left hand part. There are altogether ten transmitters in the opera house, five of them on the right and five on the left side of the prompter's box, just in front of the footlights, and each of these transmitters supplies eight or ten telephones in the Exhibition building. The telephonic system employed is that of M. Ader. The transmitter is on the ordinary microphonic plan first employed by Crossley, and contains several little bars of carbon, which, by their vibrations under the action of the singer's voice, cause variations of resistance in the primary circuit of a small induction coil, and thus produce currents in the secondary coil which is joined on to the line wires leading to the distant station. The receiving telephone which you hold to your ear is very compact, and is shaped something like a stirrup, consisting mainly of a steel horse-shoe magnet whose pole-pieces, round which the current circulates, are close to a thin iron diaphragm. There is one special feature, and that is that on the opposite side of the diaphragm there is a ring of soft iron passing opposite the two pole-pieces, its function being to intensify the magnetic force upon the diaphragm.

The electric lights were of two classes, which are called respectively, "arc lights" and "incandescent lights." The former are the most powerful ; the latter are the steadiest. The incandescent lamps are all very much on one plan. They contain a filament of carbon some few inches long, of about the thickness of a piece of thread, which is suspended by its two ends in

the interior of a glass globe of about one-fourth pint size, which has been very perfectly exhausted of air by means of the effective mercury pump devised by Crookes, as an improvement on the original mercury pump of Sprengel. There were four different forms of this incandescent lamp exhibited, bearing the names of Edison, Swan, Maxim, and Lane Fox. Swan's lamps, which were used for lighting the Congress Room, the British Bureau, and the Buffet, behaved exceedingly well all the time, and, as far as I could judge, were absolutely free from any flickering. Some of the others met with mishaps which prevented them from appearing to full advantage; but I believe that all of them when properly supplied with current are equally steady. Their light is yellower than that of an arc lamp, though not so yellow as gas. The little carbon filament in its incandescent condition is so bright that, by what optical writers call irradiation, it appears from one-eighth to one-fourth inch in diameter. You can light any number of them, or extinguish them instantly; and arrangements are sometimes provided by which you can turn them up or down to any degree you please by what looks like an ordinary tap. The Swan lamp has been adapted by Mr. Crompton to miners' use, and has been successfully employed in coal mines.

The arc lights require two rods of carbon, which must be a small distance apart, and the current passes between their ends, so that not only are the ends of the carbons luminous, but there is also an incandescent space of air, filled probably with little particles of carbon, between. Unlike the filament of carbon of which I have just been speaking, these carbons burn away, and need to be constantly fed forward towards each other, so as to keep them at the proper distance, on which the brightness of the light depends. This "feeding" of the carbons is effected automatically by a great variety of regulators, bearing the names of different inventors, the intention being that when the distance is too great or too small it shall immediately be rectified before the difference has produced any noticeable effect on the amount of light. But it is very difficult to do this with sufficient promptness and smoothness, and hence one can almost

always detect some fluctuation of brightness, which is often aggravated by impurities and inequalities in the material of the carbons. The diameter of these carbons is usually from quarter inch to half inch, according to the power of the lamp ; but there were one or two lamps in occasional use in the Exhibition which had carbons of an inch or inch-and-half. In a few of the systems, the carbons are placed parallel to each other with some contrivancc for making the current pass across the ends and not anywhere else. In Jablochkoff's system this is secured by interposing kaolin or plaster of Paris, which reaches not quite to the ends, and burns away just as fast as the carbons ; but it was the universal verdict that of all the lights in the Exhibition, the Jablochkoff were the most unsteady. They are also said to be wasteful of power as compared with other arc lights.

But I must stop for the present my description of the objects in the Exhibition, and proceed to speak of the Congress. It was called the International Congress of Electricians, and was held under the auspices of the French Government, the Minister of Posts and Telegraphs being its President.

Communications had been addressed to the Governments of the various countries requesting each of them to appoint Commissioners whose business would be not only to select or make provision for the selection of the members to be sent from their own country to the Congress, but also to select their jurymen and look after the interests of their country in the Exhibition generally.

The French members of the Congress had a preliminary meeting, and drafted a programme which was substantially adopted. There were to be two kinds of meetings, viz. : plenary meetings, and sectional meetings, besides public lectures.

The plenary meetings were for the discussion of questions requiring an international agreement : and hence calling for a vote of the Congress.

The sectional meetings were for discussion and interchange of ideas upon various electrical questions, which might, in some instances, prepare the way for laying a resolution before a plenary meeting.

There were three sections: the first intended for the discussion of questions of electrical theory; the second for applications of electricity to telegraphy, telephony, and railway engineering; and the third for the discussion of the electric lights and other applications of electricity not included in the second section.

The general questions to be submitted to the plenary meetings were thus specified ;—

I. The discussion of the measures to be taken for arriving at the general adoption of an international system of electrical units.

II. Measures to be taken for facilitating the service of international telegraphic lines.

III. Measures to be taken for facilitating scientific international relations as regards special applications of electricity.

The Congress was opened on the 15th September, by an inaugural address from its President, M. Cochery, Ministre des Postes et des Telegraphes, and there was a splendid muster of the savans of Europe.

From Germany, we had such men as Helmholtz, Kirchhoff, Clausius, Wiedemann and Werner Siemens. From Italy, Govi, Rosetti and Ferraris. From Switzerland, Wartmann and Haggenbach. From Sweden, Nrystrom and Thalen. From Russia, Stoletow and Avenarius. From the United States, Rowland and Barker. From France, Berthelot, Wurtz, Becquerel, Cornu, Dumas, Fizeau, Jamin, Marey, Allard, Blavier, Crova, Jablochkoff, Joubert, Le Roux, Lippmann, Mascart, Mercadier, Planté, Potier, Terquem, and Violle. From England, Abel, Adams, Ayrton, Barrett, Sir Charles Bright, Chrystal, Latimer Clark, Clifton, Crookes, De La Rue, Dewar, Fitzgerald, Carey Foster, Dr. Gladstone, Gordon, Hopkinson, Hughes, Moulton, Preece, C. W. Siemens, Smith of Oxford, Willoughby Smith, Spottiswoode, Sir Wm. Thomson, and myself. The total number of members was somewhere about 300.

The Congress Room or Salle des Séances was of an ample size, and arranged so that every seat had a desk in front of it, each seat and desk being intended for two persons. The platform consisted of three tiers: the highest being for the President,

Vice-Presidents, and Secretaries ; the second (called the Tribune), was for the speaker for the time being ; and the lowest, for the Commissaire General, who may be described as the Chief Clerk. There were no stenographic reporters ; but all the front seats were allocated to La Chancellerie, that is to say, to the staff of clerks charged with the duty of taking longhand notes, and preparing an abstract of each discussion—a duty which, being able scientific men, they performed with great skill and judgment. The abstracts thus prepared were always printed and submitted for approval at the next meeting.

All the proceedings were very orderly. If anyone wished to speak, he had first to hold up his hand and say "je demande la parole" ; and on the President granting permission in the words, "vous avez la parole," he had to walk from his seat to the Tribune, and thence address the assembly in French.

After the President's opening address the hours of meeting were arranged. M. Cochery recommended us to begin every morning at eight, and this hour would have been the most agreeable to the Frenchmen ; but, in deference to the protestations of the foreigners, it was made half-past nine. This was to be the hour of meeting for the first section. The second section was to meet at two, and the third at four. This division of time appears at first sight to give an undue preponderance to the first section, but it was not so in reality : for Frenchmen leave off their business at half-past eleven and go to dejeuner.

It was well understood that the principal point to be settled by the Congress was the adoption of an international system of electrical units.

English electricians have, now for several years, been agreed among themselves in using a system, the history of which may be summed up as follows :—For a long time the standard of electrical resistance in this country as well as on the continent was what is called Siemens' unit. It is defined as the resistance at temperature 0°C of a column of mercury, a square millimetre in section, and a metre in length. The column of mercury itself was not in general use, but coils of wire were sold which were guaranteed to have this amount of resistance.

With the progress of exact knowledge, it was shown that a resistance is of the nature of a velocity, that it can be expressed as so many metres per second, and that there would be great advantages for calculation in employing units of resistance which were round numbers of metres per second. To carry out this idea, three members of a Committee appointed by the British Association carried out experiments, as the result of which they issued certain standard coils guaranteed to have a resistance of ten million metres per second. This amount of resistance has since been called the Ohm, and certain amounts of electro-motive force, of current, and of capacity, which, like the Ohm, are expressible in round numbers in the metrical system, have received the names of Volt, Weber, and Farad.

Another Committee of the British Association, subsequently appointed for selecting and naming units, recommended that everything should be based on the Centimetre, the Gramme, and the Second, and that all units directly derived from these without multiplication or division should be called C.G.S. units. They recommended that in every branch of Physics the C.G.S. units should be regarded as the chief units, though other units which are decimal multiples or submultiples of them, such as the Ohm, which is 10^9 C.G S., and the Volt, which is 10^8 C.G.S., may conveniently be used for temporary or commercial purposes.

I was the secretary of this committee, and wrote a little book illustrating the application of these recommendations to various branches of Physics. At the York meeting of the British Association I had the gratification of hearing this book commended in the warmest terms both by Sir Wm. Thomson, who was President of Section A, and Mr. Preece, the head of the Postal Telegraphs, who said it had been of the greatest possible service to him in teaching his clerks. Sir Wm. Thomson is in the habit of carrying it always in his pocket, and produced and referred to it several times during the discussions of the Congress. I was accosted in Paris by one savant after another of various nationalities who congratuated me on having produced a book which was very much wanted.

The English electricians came to the Congress with the desire of having the C.G.S. units generally adopted, together with the multiples or sub-multiples of them known as the Ohm, Volt, Weber, and Farad, which are in general use in England.

The Germans on the other hand clung to the Siemens unit, which had a German origin, and is universally employed in their country, and they were for measuring currents by the quantity of copper that a current would deposit in a given time.

The French, we understood, were on our side; but it was feared that the German patriotism and tenacity of purpose would prove formidable obstacles to a harmonious solution.

As every one felt that it would be frivolous to discuss other points till this burning question was decided or put in train for being decided, it was taken up as the first question in the first section. Sir Wm. Thomson, at the call of the President of the section, M. Dumas, opened the discussion in a very lucid and able speech, in which he paid graceful compliments to the founders of the metric system, and pointed out how that system had been developed, and in one important respect simplified by the British Association Committee. He concluded by moving that a Committee be appointed to discuss certain questions of detail, which were of too technical a character to be interesting to the members of the section generally.

He was followed by Professors Wiedemann and Helmholtz, who raised difficulties regarding the accuracy of the standards which have been constructed by the British Association, and recommended a complete separation between theory and practice—the practical unit of resistance to be Siemens' mercury unit. After one or two others had spoken, I ventured to demand "*la parole*," and threw out a suggestion which, I thought, was calculated to form the basis of a satisfactory compromise. While insisting on the importance of choosing units which had the simplest possible relations among themselves, I pointed out that this part of the work of the British Association Committees was by no means bound up inseparably with their choice of wire coils as standards, and that if a mercury standard was more permanent and more easily reproducible, there was nothing to

prevent the British Association units from being materially represented by a column of mercury instead of by a coil of wire. This is just what was agreed to in the end. (See the Resolutions at the end of the present paper.)

Altogether, the Congress had seven what were called plenary sittings—that is, meetings of the Congress as a whole. Besides these, there were six sittings of the first section and a larger number of the second and third.

Three International Commissions were resolved on. The object of the first I have already stated.

Of the other two, one was for the selection of a standard source of light, the English "candle" and the French "carcel" being both of them unsatisfactory as standards for measuring the power of electric lights.

The duties of the remaining commission are fourfold :—

(*a*) To prescribe a general plan for the observation of atmospheric electricity.

(*b*) To compile statistics relative to the efficiency of the different systems of lightning conductors, and to the question whether the networks of aerial wires which traverse our cities in connection with telegraphs and telephones are a source of danger, or of additional security.

(*c*) To systematise the observation of earth-currents through telegraphic lines.

They have, also, a fourth duty, for the imposition of which I am to some extent responsible. The circumstances were these. There was exhibited in the Belgian department of the exhibition, by its inventor, M. Van Rysselberghe, a beautiful instrument by means of which the heights of the barometer and thermometer, and four other meteorological elements* could be transmitted every ten minutes to a number of distant stations and made to record themselves there, without the assistance of an operator at either the receiving or the sending station; and only one telegraphic wire was required for the whole six instruments whose indications were transmitted. Its practical char-

* Namely, humidity, depth of water in rain gauge, direction of wind, and velocity of wind. See *Nature*, October 20, 1881, p. 588, for a fuller description.

acter was shown by the fact that every night, during a period of some hours, it was in connection with the Observatory at Brussels, and received a continuous record of the indications of the Brussels instruments.

I had studied its construction with the benefit of M. Rysselberghe's explanations, and satisfied myself that it was an invaluable instrument for enabling a director at a central station to obtain the best data for weather predictions; so when M. Rysselberghe, in the fifth plenary sitting of the Congress, described his system, and proposed that the Congress should recommend its general adoption, I was a sympathising listener.

M. Mascart, director of the French meteorological office, opposed the motion on the ground of the great expense which the general adoption of the system would involve, and the little experience that had yet been obtained of its operation.

I saw that M. Rysselberghe was not likely to get what he wanted, and I was loath to let so good a thing fall; so while M. Mascart was speaking I hastily drafted in English a resolution of a more moderate character, which, after being put into French, was unanimously adopted, M. Rysselberghe having withdrawn his own proposition in favour of it. It was, that the commission on earth-currents and atmospheric electricity be also charged with the duty of reporting on the practicability of the automatic despatch of the indications of meteorological instruments to distant stations by means of telegraphic currents.

I may add that M. Rysselberghe, before leaving Paris, gave me his warmest thanks both by letter and personally for my action in the matter.

Before the Congress had finished its sittings, the labours of the jury began. There were 150 jurors—75 for France, and 75 for the rest of the world; England having 10; Germany, 10; Belgium, 11; and the United States, 7.

Their first meeting was held on the 26th October, when they divided themselves into five groups, which at the next meeting were subdivided into fourteen classes, corresponding to the classes in which objects were arranged in the official catalogue.

I was in group 1, which included classes 3, 8, 9, 14, class 3

being magneto and dynamo machines, class 8 electric lights, class 9 electromotors and the electric transmission of power, and class 14 steam engines and gas engines which were employed for driving the above named machines. My class was No. 3, magneto and dynamo machines. Before proceeding to our separate work in the classes, we appointed (upon my proposition) three small temporary Committees to draft a plan for experimental measures in the three departments of mechanics, electricity, and optics, and I was made chairman of the electrical Committee. When these Committees had given in their Reports, one large Committee, of which I was also a member, was appointed to carry out the experiments, and these experiments lasted for several weeks, having been concluded only about a fortnight ago. For several days the fourteen classes of jurors were busily occupied in visiting the objects in their several departments, making notes as they went, and receiving explanations from the exhibitors. Then each class spent some days in deliberation and judging, the latter operation being performed by a numerical process. Each juror stated a number which in his opinion represented the merit of the object under discussion. The average of these numbers was then taken and recorded by the Chairman as the official verdict.

Our Chairman in class 3 was Professor Clausius, of Bonn, well known as one of the pioneers of the modern science of Thermodynamics. We also numbered in our ranks, Professor Amsler, of Schaffhausen, inventor of the well known planimeter; Professor Kundt, of Strasbourg; Professor Potier, of the École Polytechnique ; Terquem, of Lille ; Ferraris, of Turin ; and Rowland, of the Johns Hopkins University, who was afterwards replaced by Michelson, the measurer of the velocity of light. The only Englishman besides myself was Major Armstrong, who was well versed in the subject from having superintended the experiments of the English Government on the Electric Light at Chatham.

Our Secretary was an Italian Captain of Engineers, Botto by name, who was exceedingly fluent in the French language, and had made a special study of the subject of our class, having

written a history of magneto and dynamo machines. We worked most harmoniously together, and there was very little tendency to national partizanship.

The Classes reported their judgments to their respective Groups, and the results were finally revised by the whole jury. The number of gold medals awarded was 79 ; of silver, about 150 ; and of bronze, about 250. The highest distinction of all, not counting the complimentary awards to governments and societies, was the Diploma of Honor given to inventors. Of these there were only 11, which were awarded to Sir Wm. Thomson, Dr. Werner Siemens, Professor Hughes, M. Gaston Planté, Mr. Edison, Professor Graham Bell, M. Gramme, Professor Pacinotti, Professor Bjerknes of Christiania, M. Marcel Depretz, and M. Baudot. Most of these names will be well known to you, but the last three or four are probably unfamiliar. M. Baudot is the inventor of a very elaborate method of sending several telegrams at once, and making them print themselves in Roman letters. M. Marcel Depretz has paid great attention to the theory of the distribution of electricity, and was the organiser of a large proportion of the electrically driven apparatus in the Exhibition. Professor Bjerknes was the exhibitor of some very striking experiments on mutual attractions and repulsions between vibrating bodies immersed in a liquid. He had little drums, with indian rubber ends, which were made to bulge out and draw in with rapid alternation by means of quick-acting pumps which alternately forced air in and withdrew it several times in a second. The little drums, being immersed in water, attracted one another when their phases of vibration were similar, and repelled when they were opposite. He had many other experiments on the same subject, the action in some being directive rather than attractive or repulsive. The connection between these experiments and electricity consisted in an analogy which they were supposed to bear to electricity and magnetic actions. They were supposed, indeed, to throw some light on the nature of electricity. They were certainly very suggestive.

Some of you will remember the name of Pacinotti in con-

nection with a lecture which Dr. Andrews gave in this room on the Gramme Machine. He was the first inventor of the ring armature, which was afterwards reinvented and made a great commercial success by Gramme. Pacinotti's original machine, and two others subsequently constructed by him, were exhibited in the Exhibition: and special attention was called to them by a lecture given upon them by Professor Govi, at a meeting of the Society of Telegraph Engineers which was held in the Congress Room. The question of priority was established by Pacinotti's description of his first machine in the "Nuovo Cimento" for 1864, which was put in evidence, and the machine itself was carefully examined. Dr. Andrews gathered from the information at his disposal that the contacts for collecting the currents were made in the wrong places, but this impression was erroneous, the contacts are made at the right places, and it is clear that Pacinotti well understood the theory of the machine. He was present at Professor Govi's lecture, and I met him several times afterwards.

As to addressing an audience in French, it is an exceedingly formidable thing to contemplate for the first time, and I almost shuddered at my own hardihood when I first said "je demande la parole," and proceeded to the tribune to address an audience comprising the most eminent men of science of France and the Continent. It was like plunging into deep water without knowing whether I could swim; but after the first shock was over I enjoyed the excitement; and as the vocabulary of the subject under debate had become familiar to me by listening to previous speakers, my course was tolerably easy after I was once started. The report in the official procès-verbal, as well as the resumé with comments in *La Lumière Electrique*, showed that I succeeded in making myself understood.

Indeed, I think that as a rule the English and German speakers were better understood than the French; most of the latter spoke too fast and in too low a voice to be clearly heard.

The leading spirit in the Congress was unquestionably Sir Wm. Thomson. His masterly acquaintance with the various subjects which came under discussion was very conspicuous, and

the spendid pluck which he evinces alike in attacking a scientific difficulty, or in plunging into the intricacies of a French sentence, carries all before him. He told me he had never addressed an audience in French before, but he is evidently thoroughly at home in French scientific terminology; and his clear ringing voice was of great advantage in the Congress Room, which, having a lofty canvas roof, and draped walls, was very stifling to sound.

Next to him was Professor Helmholtz, who has likewise a masterly acquaintance with every branch of Physics.

Among the Frenchmen M. Mascart appears to be the leading spirit. He is an energetic man of business, a ready and lively speaker, with a particularly clear articulation, and has done some good work in inventing and simplifying apparatus for the observation of atmospheric electricity. He is young enough to have a long future before him, and he has taken the leading part in putting his countrymen *en rapport* with the progress of electrical science in England. He is Regnault's successor at the Collège de France.

M. Cornu, of the Ecole Polytechnique, is another rising man.

The venerable M. Dumas, one of the two perpetual secretaries of the Academy of Sciences, made a very popular President in the first Section of the Congress as well as in the first Group of the Jury.

M. Cochery, who was Minister of Posts and Telegraphs in two Cabinets, and now retains the same office in a third, is an able administrator, and took us rapidly through our business in his discharge of the duties of President of the Plenary meetings. I seem still to hear his cheery voice putting questions to the vote, in the words, "Ceux qui sont de cet avis veuillent bien lever les mains."

I had once the honour of dining at his official residence with a party of eighty, and he also favoured me on one occasion with a ticket admitting six to the Ministerial box at one of the theatres.

I met numerous old friends with whom I had much pleasing intercourse, and made several new friends both among my own nation and foreigners.

It affords me much satisfaction in looking back upon this active period, when there was necessarily much discussion and difference of opinion, to reflect that I cannot recall a single instance of an unkind word given or received, and that some of those with whom I had the keenest controversy were afterwards the most marked in their demonstrations of friendship.

[Reference may be made to an article in *The Times*, of June 13, 1882, page 4, by the author of the present paper, for an account of the various kinds of magneto and dynamo machines.]

Resolutions adopted by the International Congress of Electricians at the sittting of September 22nd, 1881.

1. For electrical measurements, the fundamental units, the centimetre for length, the gramme for mass, and the second for time, are adopted.

2. The Ohm and the Volt (for practical measures of resistance and of electromotive force or potential) are to keep their existing definitions, 10^9 for the Ohm, and 10^8 for the Volt.

3. The Ohm is to be represented by a column of mercury of a square millimetre section at the temperature of zero centigrade.

4. An International commission is to be appoined to determine, for practical purposes, by fresh experiments, the length of a column of mercury of a square millimetre section which is to represent the Ohm.

5. The current produced by a Volt through an Ohm is to be called an Ampère.

6. The quantity of electricity given by an Ampère in a second is to be called a Coulomb.

7. The capacity defined by the condition that a Coulomb charges it to the potential of a Volt is to be called a Farad.

10*th January*, 1882.

The President, Robert Lloyd Patterson, Esq., in the Chair.

A Paper was read by Joseph J. Murphy, Esq., F.G.S., on

THE RAINY OR POST-GLACIAL PERIOD.

The views of the lecturer on the nature and cause of the glacial climate were submitted to the Society, on the 1st Dec., 1875, and on the 21st December, 1880;—both papers were fully printed in the Proceedings, so that it is not necessary to say anything here respecting the astronomical causes of glaciation. It is enough to repeat the conclusion there stated, that glaciation was due neither to great winter cold nor to low mean annual temperature, but chiefly to a cold summer which left the snow of winter unmelted, and partly to a great snowfall during winter. If any form of the astronomical theory of glaciation is true, the whole earth was never glaciated at the same time, but the northern and southern hemispheres were glaciated alternately; the epochs of maximum glaciation of the two hemispheres being separated from each other by an interval of 10,500 years. In each hemisphere there was consequently a succession of glacial periods, with a succession of non-glacial periods alternate with the glacial ones. Mr. Croll, in his work on *Climate and Time*, has submitted evidence of this intermittent character of the glacial climate.

On the astronomical theory of the glacial climate, these alternate glacial periods in the two hemispheres succeeded each other during the continuance of a much longer period, during

which the excentricity of the earth's orbit was unusually great. Of course, the excentricity, and with it the intensity of the recurrent glacial periods, increased and decreased gradually; and the glacial periods which occur while the excentricity is attaining, or has passed, its maximum, and which consequently never attain a maximum of glaciation, are what I call rainy periods. In strictness, the title of this paper ought to be "The rainy, or pre- and post-glacial periods"; but I say post- rather than pre-glacial, because pre-glacial deposits, or any evidence of the pre-glacial state of things on the surface of the earth, are likely to have been destroyed by the glaciers of the period of maximum glaciation; while the surface of the earth has been in many places preserved just as it was when the glaciers of the last glacial period disappeared.

As a rainy period was only an imperfectly developed glacial period, it follows that, in each hemisphere, rainy periods were alternated with dry or at least not-rainy periods; and I have now to state what appears to be geological evidence of this. Professor Blytt, of Christiania, appears to have discovered in the great bogs of his own country evidence of alternate wet and dry periods of considerable length, and beginning from the subsidence of the last glacial period. The following is from *Nature*, of 29th December, 1881:—

"In a recent number of *Naturen*, Prof. Axel Blytt concludes the highly interesting series of papers in which he has at some length expounded his theory of the immigrations into Norway, of different floras, during early dry and wet periods. On carefully examining the oldest Norwegian turf-bogs, he finds, as Prof. Steenstrup has shown in Denmark, that four distinct turf layers may be traced, between which there are frequently two or even three equally distinct deposits, composed of the roots and other remains of trees. The latter are found *in situ*, and by the undisturbed condition of the turf-beds above and below them, they afford a conclusive proof that such severed trunks cannot have been cut down by human agency. These separate tree-beds the author regards as mementoes of long periods of dryness, which may have endured for thousands of

years, and during which the formation of turf was arrested, to be resumed again when a wet period supervened. Such interrupted periods of dryness and wet he considers to be closely related to the several long-interrupted glacial periods which, according to Geikie, have succeeded one another. In accordance with Herr Blytt's view, the close of the first glacial age was followed by a dry period, in which an Arctic flora appeared in Scandinavia, traces of which, as leaves of *Dryas octopetala* and *Salix reticulata*, have been found in the clay underlying the bogs in Denmark and Southern Sweden, in the latter of which the same flora is to be seen interposed between two ancient moraines. The boreal flora, the author is of opinion, we may refer to a dry period, characterised by great summer heat; and in the deposits belonging to this age we find abundant remains of such deciduous trees as the hazel and the *Prunus avium*, which are now of rare occurrence in Norway, while many other vegetable forms represented in these beds have been long extinct. The differences observable in the bogs of Denmark and Norway, Herr Blytt refers to the fact that while the former has undergone very little if any elevation, the latter has risen since the glacial age 600 feet above the level of the sea. In Norway the formation of the turf-beds may be gauged by their varying elevations. Thus in South-east Norway, where the old sea-level has been raised to a height of 600 feet, the turf is from 20 to 26 feet deep, while at low levels, as 30 feet above the strand, the bogs are seldom more than from two to four feet deep."

In Sir Joseph Hooker's address to the Geographical Section of the British Association, in 1881,† he thus resumes Professor Blytt's facts respecting the stratification of the bogs:—

"The proofs of the alternating wet and dry seasons rest on the fact that the different layers of peat in each bog present widely different characters, and these characters recur in the same order in all the bogs. First, there is a layer of wet spongy peat, with the remains of bog mosses and aquatic plants; this gradually passes upwards into a layer of dry soil containing the remains of many land plants and prostrate trunks of trees,

† Reported in *Nature*, 8th September, 1881.

showing that the country was forested. To this succeeds wet spongy peat as before, to be again covered with dry peaty soil and tree-trunks, &c., and so on."

Respecting the great precipitation of the glacial climate—including in precipitation, of course, both rain- and snow-fall—I take the following evidence from Professor Geikie's paper on "The Geysers of the Yellowstone," in *Macmillan's Magazine*, May, 1881:—

The Great Salt Lake of Utah, North America, is 5,250 feet above the sea, and is at present without outlet, and only 80 miles long by 52 broad. But at a height 940 feet above its present surface, a terrace has been discovered which is without doubt an ancient shore of the lake, and corresponds in height with a gap in the rim of the lake-basin, by which the lake overflowed in a river which was a tributary of the Snake River or Upper Columbia. An examination of the terrace shows that the lake then extended 300 miles by 180, so that its area was then, speaking roughly, about twenty times what it is now. The moraines of ancient glaciers show that the glaciers which produced them came down to the lake from the Wahsatch mountains, which are only about 3,000 feet higher than its surface at that time. Freshwater shells are found along the terrace, but they are not needed to prove that a lake with an outlet must have been of fresh water.

We see from these facts that whereas the precipitation of Salt Lake Basin is now carried off by the evaporation of the Salt Lake, at a recent geological period, which was probably the glacial, the precipitation of the same area filled a lake of twenty times the extent, and was not all carried off by its evaporation, but part of it overflowed in a river. This proves either that the quantity of precipitation must have been much greater than now, or the force of evaporation much less;—probably both.

7th February, 1882.

The President, Robert Lloyd Patterson, Esq., in the Chair.

Professor Letts, Ph.D., F.R.S.E., read a Paper on

THE DIAMOND.

The Diamond, on account of its great beauty, rarity, and extraordinary hardness, has been held in high estimation from very early times. The word diamond is derived from the Greek "adamas," indomitable, a term applied to it on account of its real property of extraordinary hardness and its supposed property of resisting fire—that is, of not becoming hot when heat was applied to it. But its hardness was exaggerated by the ancients. For instance, Pliny says: "The best of all these diamonds is made upon an anvil by blows of the hammer, and their repulsion for iron is such that they make the hammer fly in pieces, and sometimes the anvil itself is broken." This statement is still believed in by some people, and has occasioned a considerable loss of property.

By the ancients precious stones were regarded as possessing supernatural powers, and they were accordingly employed as talismans, each species possessing its own peculiarities. The diamond was carried as an antidote to poisons and a preservative against insanity. As an ornamental stone, the diamond was highly esteemed during the early times of the Roman Empire. As early as the first century diamonds had already been brought from India, and from that time till the eighteenth century, practically, the whole supply of diamonds was brought from the

East Indies. The most celebrated of all the Indian diamond mines were those in the neighbourhood of Golconda, near Hyderabad, which have yielded the finest diamonds in existence ; among others, the Kohinoor. In the 17th century as many as 60,000 people were employed in the mines of Golconda, and in the 13th century upwards of 400lb. of the precious stones which had been taken from the mines were stored in Sultan Mahmoud's treasury. The Golconda mines were ceded many years ago to the English, but they are believed to be exhausted, and have long since been abandoned.

In the 18th century diamonds were discovered in Brazil by gold-seekers, who were in such ignorance of their nature that they employed them as counters in card-playing; but at last a native, Bernard Lobo, who had visited the East Indies, recognised the true nature of the counters, and immediately the news spread like wildfire, occasioning a panic in the diamond market. Upon the inhabitants of the diamond district the discovery acted like a curse, and to the bitter sorrows of persecution were added the horrors of earthquake and drought. The existence of diamonds in South Africa had been several times asserted before the English conquest of Cape Colony. The re-discovery, however, took place in 1867. At that date a shrewd trader, passing through a country forty miles to the west of Hopetown, saw the children of a Boer called Jacobs playing with pebbles picked up along the banks of the Orange River. Struck with the appearance of one of the playthings, the trader told Jacobs that it reminded him of the white shining stones mentioned in the Bible. As he uttered the words, an ostrich-hunter named O'Reilly chanced to pass the door-way of the house, and overhearing the remark, he entered, and was also impressed. Vague ideas of a diamond, which none of the three had ever seen, passed through their minds. They tried the pebble upon glass, scratching the sash all over. A bargain was struck ; O'Reilly took the stone for sale, each of the parties present to have a share. At Capetown, on the verdict of Dr. Atherstone, Sir P. E. Wodehouse gave £500 for it. The news spread fast.

At the moment of this discovery there was something exceed-

ing a panic in the colony. Wool, the staple product of the colony, was at a hopelessly low price ; a murrain was thinning the sheep ; never had merchants known such a time of anxiety ; and this great excitement overtook the colony, and search was made for diamonds in all directions. In 1869 a Hottentot shepherd discoverd the far-famed "Star of South Africa." He first offered it in a store for £200, but the assistant, in his master's absence, refused the offer ; eventually he sold it for £400 to the trader who saw the Boer's children playing with diamonds. The fortunate purchaser disposed of it next day for £12,000. In December, 1870, it was whispered that the children of Duboit, a Boer, were in the habit of picking up diamonds on their father's farm, which was situated twenty miles from any river. The farm was "rushed," and thousands of diamonds were soon unearthed from these "dry diggings" or beds, in which many believe the diamond was created. A tremendous rush to the diamond fields occurred, adventurers crowded thither from all parts of the world, and with such extraordinary rapidity that in 1872 there were 50,000 souls engaged in digging. An eye-witness says that about this time New Rush alone was yielding from £12,000 to £15,000 a day. One of the most striking peculiarities of some of the African gems is their liability to crack or explode spontaneously. Some Indian diamonds also have been known to explode.

Diamonds have been found in other places besides those I have mentioned. It has been stated that a diamond was once found in a brook in Ireland, but the statement requires confirmation.

The lustre of the diamond, or the manner in which light is reflected from its surface, is very characteristic, and is one of the reasons of its popularity as a gem. The diamond possesses another optical property in a high degree, a property in which it is prominent among precious stones—the power of changing the course of a ray of light. The extreme hardness of the diamond affords a ready means of distinguishing between it and other stones. But, although very hard, the diamond may be broken into fragments in a steel crushing mortar, and the frac-

ture of the diamond thus effected occurs in directions parallel to the faces of the octahedron, which proves the octahedron to be its primary form. A great many crystals admit of being fractured in certain directions, which are, therefore, called planes of cleavage. Advantage is taken of the brittleness of the diamond in roughly shaping it previous to its being polished.

The colour of the diamond is a matter of considerable importance as regards its value. When the diamond is colourless and perfectly transparent, it is said to be of the "first water," and is highly prized. But it frequently happens that the stone is slightly yellow or brown, technically called "off colour," and this is éspecially the case with Cape diamonds. An "off colour" stone is, comparatively speaking, of little value, unless the tint is very pure. Diamonds are sometimes found coloured green, blue, rose, and even black. They then become fancy stones, and their value is greatly beyond the first-water gems. The lovely blue diamond formerly owned by Mr. Hope, and called the Hope diamond, is quite unique. I believe it was purchased for £18,000, and sold to the Duchess of Newcastle for £25,000. Its value may be even greater. The colour of certain diamonds may occasionally be modified by heat, and a remarkable example of this was observed in France some time ago.

Months of labour, even years, with the improved machinery of the present day, must be expended on a stone of large size in order to convert it from the rough natural form into the polished brilliant. During the whole of this time, the greatest care must be bestowed on the manipulation, as a single mistake would mean the depreciation of the value of the stone to the extent of hundreds or even thousands of pounds. The natural shape of the diamond is but little fitted for displaying the full beauties of the stone, and it generally happens that the diamond in its rough form has certain imperfections which greatly detract from its appearance. The object of the diamond cutter is to remove those portions of the jewel in which the flaws occur, to give the crystal a symmetrical and elegant shape, and, by multiplying the faces of the diamond, to cause it to reflect as much as possible of the light which falls on it, and

thus to produce the beautiful flashing effect and play of colours which can be obtained with no other stone, at least to nothing like the same extent, owing to its great refractive power. Diamond cutting and polishing were practised in India and China long before its introduction into Europe, which is stated to have been done by Louis de Berguem, an inhabitant of Bruges, towards the latter part of the 15th century. At all events, he appears to have been the first to employ a polishing wheel with diamond dust, and, when suggested, a suitable arrangement of facets for displaying in a high degree the reflecting and refracting powers of the diamond. Berguem's pupils emigrated to other European towns, and established workshops for cutting the diamond; and at the present day such workshops can be found in London, Paris, New York, Boston, and especially Amsterdam, which is the seat of the diamond cutting industry, and in which the largest establishment for the purpose exists, namely, that of Mr. Coster. The diamond is cut in several different forms, but only two of these, the brilliant and the rose, are common. The brilliant is derived from the octahedron, the natural form of the diamond, by replacing the point of intersection of four of its edges by one or by several faces. The brilliant complete has 66 faces. In the rose one surface is quite flat; the other is convex, and is divided into a variable number of facets. The Holland Rose has 24; the semi-Holland, 18 to 20.

The operations by which the rough diamond is fashioned into the brilliant, rose, or other form are splitting, cutting, and polishing. In splitting the diamond it is first embedded by means of cement into a wooden handle, and the workman then scratches a deep V-shaped notch on its surface at the place where he wishes the fracture to occur. This he does by means of a sharp-pointed diamond, which is fixed into a handle. When the notch is sufficiently deep, the handle embracing the diamond is placed in a hole in a block of lead, and with one hand the workman applies the edge of a small steel ruler to the notch, whilst with the other he gives a tap to the ruler, and the stone is split. A spectator says: "It is not without emotion that

one sees the blow given, for the slightest error may prove fatal to the value of the diamond for ever; but it is given without hesitation and with perfect composure. The future of a rough diamond is very much at the mercy of the splitter; for it is he who decides what shape the stone is to take, and how the flaws and other imperfections are to be removed so as to retain the utmost weight with the most brilliant effect. The split diamond is next passed to the cutter, who operates upon two stones at the same time, each being cemented into wooden handles. These he grinds together, so as to accomplish their mutual smoothing. His labour, which is of a very heavy description, has given rise to the saying, 'diamond cut diamond.' The cutter, having roughly fashioned the diamond into the desired form, passes it to the polisher, whose business it is to smooth the rough parts which the cutter has formed, and to give each a bright polish. The diamond is first embedded with great care and judgment in an oval mass of tin and lead to serve as a support, this in its turn being fixed into a brass cup, which is provided with a handle. The polishing wheel consists of a disc of steel, revolving in a horizontal direction at a speed of 2,000 revolutions per minute. The polishing is effected by smearing this wheel with diamond powder and oil, and then pressing each part of the diamond against it. The eyes of the polishers seem of little use compared with their sense of touch, which has been exquisitely educated. It is by the instinct of their finger ends that the point of the diamond is adjusted with determinate exactness of position to the face of the revolving disc."

It is now time for me to tell you the histories of some of the more celebrated diamonds, several of which are quite romances, and unfortunately, too often tragic ones. Of course such a theme has not escaped the notice of the novelist, and in support of my statement I need only remind you of Wilkie Collins's celebrated book "The Moonstone," the plot of which is concerned with the diamond which is now in possession of the Russian Crown, and is called the Orloff. It is the most remarkable of the Crown jewels of Russia, and forms the end of

the Imperial sceptre. It is of Indian origin, and for a century and a half formed one of the eyes of the famous idol Serringham or Sherigam, in the famous temple of Brahma, another and similar diamond forming the second eye. At the commencement of the eighteenth century, a soldier, who was one of the French garrison in India, determined to get possession of both eyes of the idol. With this object he pretended to be a convert to the Hindoo religion, and to show extraordinary zeal in its behalf. Eventually he so cleverly imposed on the priests of the temple that he was entrusted with the care of the temple. He waited patiently for his opportunity, and on a dark and stormy night he succeeded in wrenching one of the eyes from its socket, but failed in his attempt to remove the other. Taking to flight, he reached Madras, where he disposed of the diamond to a captain in the English navy for £2,000. On its arrival in England the diamond was purchased for £12,000 by a Jewish merchant, and sold by him to Catharine II. for £4,000 and a title of nobility.

Another diamond with an interesting and romantic history is the Sancy, which is not cut as a brilliant, but in a special and peculiar manner, and is said to have been the first stone cut in Europe, the act having been accomplished by Louis de Berguem. Charles Duke of Burgundy wore it in his helmet at the battle of Morat in 1476, and after the Duke's defeat it was found in the battle-field (another account says removed from the corpse of Charles) by a Swiss soldier, who sold it to a priest for a couple of francs. It was not heard of for some time, but in 1589 it was pledged by King Anthony of Portugal to De Sancy, a Huguenot gentleman, and treasurer of the King of France, who retained it in payment of 100,000 livres. In this family it remained until Henry the Third commissioned a descendant of the purchaser to raise recruits in Switzerland ; and very shortly afterwards, driven from the throne by his subjects, the King borrowed the stone to pay his troops, but the servant who was carrying it to the King disappeared, and was not heard of for some time. At last it was discovered that he had been assassinated in the forest of Dole, and buried in a native village. "Then, my

diamond is not lost," said De Sancy, and so it turned out, for it was found in the stomach of the faithful servant. In 1792 the Sancy once more disappeared, and was found by the Paris police.

The next celebrated diamond I have to mention is a brilliant of almost unrivalled beauty called the "Pitt," or "Regent," which is in possession of the French Government. It was found in the mines of Parteal, near Golconda, in 1702, by a slave, who, in order to conceal it, wounded himself in the thigh, and hid the diamond in the wound. He promised the stone to a sailor if he would gain him his liberty. The sailor got the slave on board, then took the diamond from him, and drowned the unfortunate wretch. The sailor sold the stone to Pitt, grandfather of the Earl of Chatham, and Governor of Fort St. George, for £1,000; then spent the money, and eventually hanged himself. Pitt sold the diamond to the Duke of Orleans (Regent of France during the minority of Louis XV.). Since then the "Regent" has had many curious adventures, and has passed very literally through many hands. For in the days that followed the fall of Louis XVI. the "Regent," carefully chained and guarded by gendarmes, was exposed to the people of Paris, and every half-starved workman who chose might hold the symbol of Royal splendour in his hands for a few minutes. The "Regent," pawned to the Bavarian Government by Napoleon I., stolen by robbers, and its hiding place revealed at the gate of death by one of the reckless band, and mounted in the state sword of Napoleon I., glittered in the imperial diadem through the palmy days of Napoleon III., and is now likely to pass through a new cycle of adventures, as it is to be disposed of with the other jewels of the French Crown.

The history of one more celebrated diamond must detain us for a few moments, that which is the chief ornament of our own crown and which glitters in it along with many other gems. Every one of you has heard of the Kohinoor, or "mountain of light." The history of it is obscure, and is traced back to the legends of India. According to one of these it was worn by Carna, one of the heroes of the Indian epic poems, and if this is

the case it must have been unearthed about 4,000 years ago. It was in possession of the Rajah of Ujazin, 56 B.C. It was regarded as a talisman of power, and was always the booty of the conqueror. It passed to the Sultans of Delhi, and at length came into the possession of Runjeet Singh, and in 1850, after the formal cession of the Punjaub to British India, it was presented to Lord Dalhousie as Viceroy to her Majesty. In its original form as brought from India the Kohinoor was valued at £140,000. It had several surface flaws, and was by no means of an elegant shape. It was therefore decided to re-cut it, and it was sent to Cosler's establishment at Amsterdam in 1852. The Duke of Wellington was the first to place it on the cutting wheel, and, after thirty-eight days' of incessant labour, the diamond was fashioned into a magnificent and perfect brilliant, but its weight was reduced from $186\frac{1}{16}$ to $122\frac{3}{4}$ carats. However, the improvement in its shape and brilliancy fully compensates for this.

The "Hope" diamond is quite unique, as it is of a beautiful sapphire blue colour. Its weight is $44\frac{1}{8}$, carats, and it was purchased by Mr. Thomas Hope for £18,000. It has been sold to the Duchess of Newcastle for £25,000. Among the diamonds found in Brazil is one which belongs to the King of Portugal. It is said to weigh 1,680 carats, and in Brazil its value is estimated at three hundred million pounds ; but it has been suggested that this diamond is topaz, in which case the millions vanish.

The concluding portion of the lecture consisted of a sketch of the diamond from the chemist's point of view, showing that chemists had demonstrated it to be carbon :—"As to the origin of the diamond there is little to be said, for nature seems to have decided that the operations which she employed for producing it shall remain a mystery. Many attempts have been made to obtain the diamond by artificial processes, and I venture to think that if chemists have not triumphed already, they will do so eventually. Whether diamonds will ever be obtained of large size artificially is a question that time alone can decide."

7th March, 1882.

The President, R. L. Patterson, Esq., in the Chair.

A Paper was read by Professor Cunningham, M.D., F.L.S., on

CORALS AND CORAL ISLANDS.

ABSTRACT.

After a reference to some popular misconceptions with respect to the nature alike of corals and coral-forming animals, and a short notice of certain calcareous bodies, animal and vegetable, liable to be confounded by the uninstructed with these formations, it was stated that all true corals were the internal secretions of animals included in the sub-kingdom Cœlenterata, the great majority being the skeletons of Actinozoa, while a certain number, as revealed by recent researches, are those of Hydrozoa.

The Actinozoan corals were first treated of, the typical structure of an Actinozoon, as illustrated by a common Actinia or Sea-Anemone, being described ; and it was shown that, in accordance with the number of tentacles and of the vertical radiating partitions (or mesenteries) of the body-cavity, the members of the class might be included in one or other of two groups—*i.e.*, those possessed of numerous tentacles and mesenteries (*Polyactinia* or *Zoantharia*), and those with only eight tentacles and eight mesenteric folds (*Octactinia*, or *Alcyonaria*).

Of the coralligenous Polyactinia, some resemble the Sea-Anemone in being *solitary* animals, each living being having a

separate and independent existence, and developing a simple coral in its body-wall, while the larger number are social, being composed of numerous living beings in organic union with each other. In this latter case we meet with a compound coral, certain parts of which are formed in the bodies of the various members of the colony, while others are the secretion of the soft bond of union which binds the colonists together.

The more important points of the structure of simple and compound Polyactinian corals were indicated, and it was pointed out that in the same manner that a hexamerous symmetry was usually distinguishable in the number of the tentacles and mesenteries, the hard septa or vertical radiating portions of the coral exhibited a corresponding arrangement. Notice, however, was taken of the fact that in a considerable number of extinct forms of Polyactinia (those designated Tetracoralla or Rugosa) the septa formed multiples of four, and that in some of the species the coral exhibited the singular peculiarity of a calcareous plate or operculum, with which its calice was closed.

The Octactinian corals were next examined, and the various modifications examined. Beginning with the very rudimentary peculiar skeleton of *Alcyonium*, the various forms of skeleton possessed by the *Pennatulidae*, *Gorgonidae*, *Tubiporidae*, and *Helioporidae* were exhibited and described ; and reference was made to the important discoveries of Professor Mosely in connection with the last family.

The first part of the lecture was brought to a conclusion with a brief notice of the Hydrozoan corals, of which two recent families, *Milleporidae* and *Stylasteridae*, are now known ; and it was stated as not unlikely that the problematical extinct *Stratoporidae* belonged to the same class.

The second portion of the lecture was occupied with a *resumé* of some of the more important points connected with the structure, the geographical and bathymetrical distribution, and the growth of coral reefs ; a sketch of Mr. Darwin's hitherto generally accepted subsidence theory being given, and certain objections to it recently advanced by Mr. Murray, of the Challenger expedition, shortly noticed.

Corals of one kind or another are more or less plentiful throughout the seas of the globe, but the reef-forming species are restricted to certain regions, and the areas which they occupy are determined by the temperature of the ocean, depth, nature of the shore of the adjoining land, and other circumstances. All appear to require an equable and elevated temperature in order to flourish—this temperature, according to Dana's observations, being not below 68° F. Further, no reef-form seems to be capable of living and thriving, except at depths exceeding 20 to 40 fathoms ; and in some cases the growth of reefs appears to be prevented by the nature of the coast, though additional researches are required on this point.

Navigators have been long accustomed to divide coral reefs into three groups, namely, *fringing* or *shore reefs*, *barrier reefs*, and *atolls*, or *lagoon islets*. Of these, the first are found skirting the coasts of islands and continents at distances varying from less than half a mile to one or two miles. The outer portion of such reefs is higher than the inner, in consequence of the stronger corals growing more vigorously where they are exposed to the wash of the waves, and the channel between the reef and the land has in most cases a sandy bottom. The second class (barrier reefs) either extend in straight lines in front of the shores of a continent or great island, or encircle smaller islands, being separated from the land by a broad and rather deep channel, the calm water of which usually presents a striking contrast to the violent surf which breaks on the outer margin of the reef. In some cases the entire line of reef is converted into land, but usually only limited portions of it are so, assuming the form of low islands more or less clothed with vegetation, of which the cocoa-nut palm is a prominent feature. The last kind of reefs—atolls, or lagoon islands—are annular in form. They vary much in dimensions, and surround calm expanses of water destitute of islands. A considerable portion of their surface is raised above the sea-level, usually presenting the appearance of a chain of small islets.

A considerable number of theories have been advanced to account for the different peculiarities of these three kinds of

reefs. Mr. Darwin's attention was attracted to the subject in the course of his voyage in the Beagle, in the years 1831-6, and his theory is based upon the facts—firstly, "that reef-building corals only flourish at a very limited depth; and secondly, that throughout areas of vast dimensions none of the coral reefs or coral islets rise to a greater height above the level of the sea than that attained by matter thrown up by the winds and waves." These reefs, consequently, must have foundations; and what is their nature? Are they formed of great banks of sediment, or do they consist of solid rock? Mr. Darwin contended that the form or disposition of the groups of atolls afford no countenance for the first suggestion, and that the latter alternative must accordingly be adopted. Fringing reefs present no difficulties for solution, as they simply occur in those limited depths where coralligenous Actinozoa are capable of flourishing, and barrier reefs and atolls represent successive stages of subsidence of the floor on which fringing reefs were erected. As the foundation sinks the coral-formers are obliged to build upwards to maintain the level at which they can exist. The upper parts of such reefs are, then, the living portions, being built upon the skeletons of their predecessors. The above view of the formation of the varied forms of coral-reef, although very generally adopted, has not, however, satisfied all those naturalists who have bestowed attention on the subject; and Mr. Murray has recently stated, as the result of his observations on board the "Challenger," that he has arrived at the conclusion "that it is not necessary to call in subsidence to explain any of the characteristic features of barrier reefs or atolls, and that all these features would exist alike iu areas of slow elevation, of rest, or of slow subsidence." He thinks that he has succeeded in proving that foundations have been prepared for these two classes of reefs by the disintegration of volcanic islands, and by the building up of submarine volcanoes by the deposition on their summits of organic and other sediments, maintaining that when "coral plantations build up from submarine banks they assume an atoll form, owing to the more abundant supply of food to their outer margins, and the re-

moval of the dead rock from the interior portions by currents, or by the action of carbonic acid dissolved in sea-water ;" further, that " barrier reefs have built out from the shore on a foundation of volcanic debris or on a talus of coral blocks, coral sediments, and pelagic shells, and the lagoon channel is formed in the same way as a lagoon."

7th March, 1882.

PUBLIC MEETING IN ST. GEORGE'S HALL.

The President, Robert Lloyd Patterson, Esq., in the Chair.

Mr. A. R. Wallace, Lectured on

ISLAND LIFE.

4th April 1882.

The President, ROBERT LLOYD PATTERSON, Esq., in the Chair.

Mr. R. YOUNG, C.E., read

NOTES ON BUN-A-MAIRGE ABBEY AND ITS SURROUNDINGS.

THE reader at the outset referred to the great interest which the north-eastern coast of the county Antrim possesses for the artist and the antiquary. The cliff scenery all the way from Larne to Portrush is probably unrivalled in respect of variety and colouring, and the mural precipices of columnar basalt, which attain their greatest height in Fair Head, near Ballycastle, add a character of peculiar solemnity to the landscape. Forming, as it did, a part of Dalriada, this portion of Antrim was in very early times brought into close relations with the western side of Scotland, and the little town which was founded at the mouth of the Mairge river, and was known subsequently as Markstown, seems to have been the chief port of communication on the Irish side. At a later time, the district of which Ballycastle may be considered the centre, became the battle-ground on which the rival clans of MacDonnels and M'Quillans engaged in deadly strife, which only ended in the complete defeat of the M'Quillans in the year 1559, on the slopes of Slieve-an-Aura, at the head of Glenshirsk.

There seems no reason to doubt that it was one of the chieftains of the M'Quillans who erected the little Franciscan monastery, of which we now see only some fragments in the picturesque remains on the banks of the Mairge river.

After giving a minute description of the Abbey Church and the monastic buildings now traceable, which was illustrated by several plans and sketches, the reader proceeded to discuss the question of the age of the foundation. He exhibited a careful drawing he had lately made of the exterior of the east gable of the church, and pointed out the evidence it contained in the remains imbedded in it of an earlier and larger window, and by a reference to drawings of similar portions of abbey churches in other parts of the North of Ireland, and specially that of Killydonnel, in county Donegal, of which the date is known, he concluded that the first building was certainly not later than 1450, and probably a good deal earlier, and that the alterations made by Roory M'Quillan about 1500, as recorded in a MS. in the British Museum, are the only and quite insufficient grounds on which to base his claims to be the original founder of the abbey.

In addition to the reader's own drawings, Mr. Lockwood lent a large plan of the abbey buildings, from actual measurements; and Dr. James Moore, R.H.A., exhibited a coloured sketch, taken a great many years ago, showing that a great deal of dilapidation had occurred since.

4th April, 1882.

The President, Robert Lloyd Patterson, Esq., in the Chair.

Mr. Isaac J. Murphy, read a Paper on

LINKAGES: A RECENT MECHANICAL INVENTION, BY MONSIEUR PEAUCELLIER.

About fifteen years ago Mons. Peaucellier, a lieutenant in the French army, living at Rennes, in Brittany, invented a simple machine by the use of which the power is obtained of producing perfectly straight lines, derived from acting on the motions of radii of circles. It appears that he remained for a considerable time, even some years, unaware of the magnitude of the importance, as of the novelty, of his invention—it may be said, of his discovery. About 1870, a student in the University of St. Petersburgh, named Lipkine, without communication with the prior inventor, made precisely the same discovery; and this at the very time when his preceptor, in all likelihood with his knowledge, was engaged in trying to prove that it is not possible to convert circular into correct lineal motion.

The machine of Peaucellier (fig. I.) is very simple; and the mathematical proof of its correctness is easy to master. It has since its first invention been subjected to various modifications, and with these modifications it has been found capable of producing circles of any radius, as well as many other curves, if not of producing any and all curves in the region of plane geometry. I wish to limit my present scope to the points I have already examined into. I therefore quote only, without following the unlimited road with all its branches which he

opens, Professor Sylvester's words:—"We are able, by this machine, to bring about any mathematical relations that may be desired between the distances of any two of the poles of the linkage (the name of the machine) from a third, and are thus potentially in possession of an universal calculating machine."

I proceed to speak of the practical and obvious use of Peaucellier's machine as applied in mechanics. The parallel motion of Watt, adopted for the purpose of giving as much directness as he was able to do to the pushing of a piston by the end or centre of a beam moving in the arc of a circle, is not perfect. As applied in the ordinary beam engine to the cross-head proper, it is so; but as applied to the air-pump piston, the supposed straight line through which its cross-head is directed is really a figure of 8. Accordingly, its frequently uneven (or wabbling) motion is apt to react on the head of the steam-cylinder piston, and to produce a tremulous vibration; which movement is sometimes incorrectly supposed to be due to a mechanical error in the parallel motion itself. The Peaucellier method has been applied with admirable success to cross-heads; in particular, the steam-engine which performs the work of the Houses of Parliament is so geared. There is, in fact, no common pump to which the plan is not applicable. It is evident that there must, in all cases, be a saving of power by substituting a direct for a crooked pushing motion.

Peaucellier has constructed linkages, or "cells," of two formations, each of seven bars; and a third linkage, based on the same mathematical principle as Peaucellier's, has been shown by a Cambridge man, consisting of only five bars—the smallest possible number capable of affording a true straight line. The original cell is (fig. I.) two equal bars (*a*), and four equal ones (*b*), connected by two equal ones (*c* and *d*), *d* being properly not a bar or rod, but the fixed distance equal to *c*. The two long bars move as the radii of a circle; the two bars (*b*) joined to *c*, move from the circumference of a circle whose radius is *c* or *d*; and the further end of the rhombus whose sides are *b*, moves, as *c* moves in its centre, so far as the limits of the machine permit, in a straight line perpendicular to

that diameter of the circle of which d is one-half. For (fig. II.) if ABC be a circle of which AB is a diameter, produced to E, and ED perdendicular to that diameter; if AD be joined by a line ACD, the angle ACB being in a semicircle is a right angle; and the angle BAC is common to the two triangles, ABC, ADE; therefore

$AE : AD :: AC : AB$: and $AE \cdot AB = AD \cdot AC$;

so that the locus of D, when the above rectangle is a constant quantity, is in a straight line perpendicular to the diameter AC; and equally so whether D be within or without the circle. Bisect CD in G; and draw any line GF perpendicular to CD; and join DF and CF. Then the difference of the squares of AG and GD is equal to the difference of the squares of AF and FC (or FD): and is also equal to the rectangle under their sum AD and difference AC; which has been shown to be constant. But AF and FD are equivalent to the a and b of Peaucellier's linkage; which accordingly succeeds in drawing a mathematically correct line in DE. Peaucellier's other cell (fig. III.) differs from this in that the four equal bars (b) have the pair of bars (a) inside them; when, to produce the straight line, the fixed bar or distance d must be linked to the pair a. If otherwise, and the bar c in either linkage were the fixed one, the traversing point D would describe a very curious curve; the law of which I shall presently state.

Peaucellier calls the original cell—that with the smaller rhombus—his positive cell; and that with the rhombus outside the pair of bars, negative. It was some time before I recognized the appositeness of these terms; preferring the more obvious ones of "external" and "internal." But I am convinced, by the consideration of the geometrical proposition on which the proof is based, that Peaucellier's names are the most logical. The proposition, stated to cover all the cases, is :—If straight lines be drawn from any point to the extremities of any diameter of a circle in the same plane as the point, the rectangle under each of such lines and its segment (or segment produced) intercepted in the circle is equal to the rectangle under the diameter of the circle and its segment towards that extremity met by each

straight line respectively, formed by the falling of a perpendicular upon such diameter (or diameter produced) from the given point;—and;—the sum of such rectangles is equal to the square of the diameter if the perpendicular falls within the circle, and their difference if it falls without it ; or their sum in both cases if one of the segments has its place in the semicircle furthest from the point, and is therefore regarded as *minus*. Now the demonstration of Peaucillier's first, or positive cell, depends on that case of this proposition in which the perpendicular from the given (or as I have shown, traversing) point on the diameter does not pass it, and its segment within the circle is part of itself, or positive ; while the demonstration of the negative cell depends on the other case. In investigating the curve produced by fixing the bar c, and moving d, as also in the case of other curves produced by the machine, I met with confirmation of this view.

If c and d are made unequal, D will describe an arc of a circle the centre of which is in d or d produced ; its radius depending on the magnitudes of the various bars of the linkage, and on the distance d, viz.:—

$$\frac{c(a^2-b^2)^*}{c^2-d^2}$$

Accordingly, when a is greater than b, and c greater than d, the concavity of the arc is towards the figure (positive cell); the centre of the circle lying in d produced in the direction of A (fig. VI.) and in the same cell, if c is less than d, the concavity of the arc is from the figure. In the negative cell, c must be less than d to draw an arc with its convexity towards the figure ; and the minus sign appears when the centre of the circle lies in the part of d produced which is away from A. I believe this is the first time in the history of mathematics that a circle has

* Assuming that the path of the point D in fig. VI. is an arc of a circle, and taking any distance e, the dotted line between C and A as a variable, we can obtain expressions for the sine and versed sine of the arc in terms of a, b, c, d, and e ; then, as

$$\frac{\sin^2+\text{versin}^2}{2\text{versin}}=\text{rad.}$$

in the simplest form of which fraction the variable e disappears, the assumption must be true.

been described from a centre (if we may so speak) not within itself. This property of Peaucellier's invention has been put to practical use.

The curve which D describes when c is fixed and d is moved is a curious one (fig. IV.) ad infinitum in each direction, always approaching but never reaching a straight line at right angles to the axis of the curve, the axis being $2\,C$. The figure is under the curve. In the negative cell its inclination is reversed. The conjugate is

$$\frac{a^2 - b^2}{2\,c}.$$

If, in the positive cell, the transverse and conjugate be made equal, the two arms of the curve will meet in a cusp; and if the conjugate be the less, they will form a loop. I have been unable to find an expression for the ordinate without using a variable. The law of the curve is :—

Abscissa : axis : : ordinate^2 : ordinate^2 + (abscissa + conjugate − transverse axis)^2.*

It remains to describe the five-linked cell. If two pairs of bars ($a\ a$ and $b\ b$) cross one another as in fig. V., at whatever angle they may be, the product of the distances AB and CD is

*The ordinate, using e as a variable, is

$$\frac{\sqrt{(2c)^2 - e^2(a^2 - b^2 - e^2)}}{2ce};$$

the abscissa

$$\frac{(2c1^2 - e^2)}{2c}$$

squaring the ordinate and dividing, we obtain

$$\frac{(a^2 - b^2 - e^2)^2}{2ce^2} = \frac{\text{ord}^2}{\text{abs}},$$

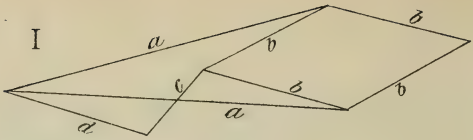
which is equal to

$$\frac{\text{diag of rhomb}^2}{\text{axis}}.$$

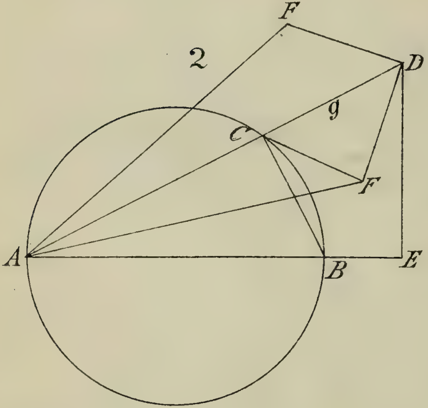
But an examination of the figure (VII.) will show that the diagonal of the rhombus is equal to the square root of the square of the ordinate + the square of the abscissa + conjugate — transverse. If the conjugate be less than the axis of the curve—that is if D be nearer to A than C is, this last quantity may become minus; but this does not affect the law of the curve, as it must be squared.

constant, being $=AD^2 \sim AC^2$. Taking any four points in a straight line parallel to the dotted lines AB and CD, viz., EFG and H, EF has a constant ratio to AB, and EG has a constant ratio to CD; wherefore EF, EG is constant; also EF, FH is constant. Thus by fixing equal links to E and F, according to the proof in the proposition, the link attached to E being stationary and that attached to F moving from the centre K, G will always traverse in a straight line perpendicular to EK, or, the link attached to F being made stationary, H will traverse, as in the negative cell, in a line perpendicular to FK.

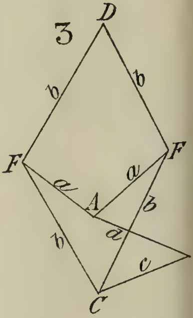
I



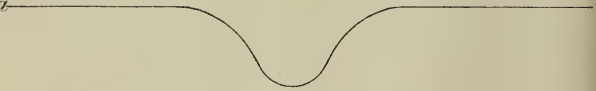
2



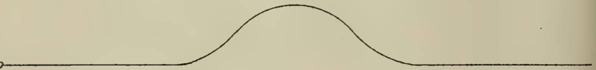
3



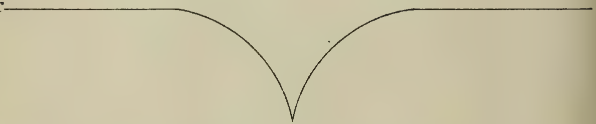
4a



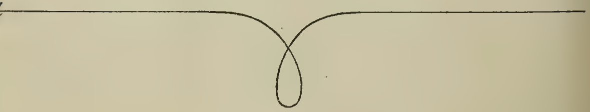
4b



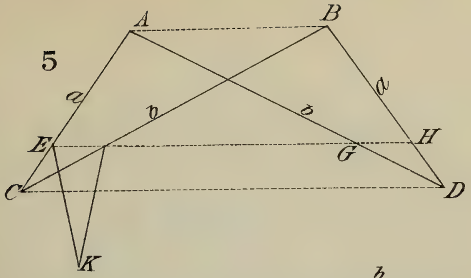
4c



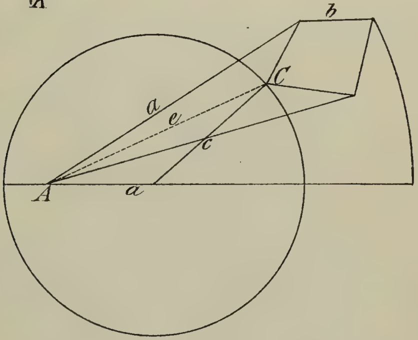
4d



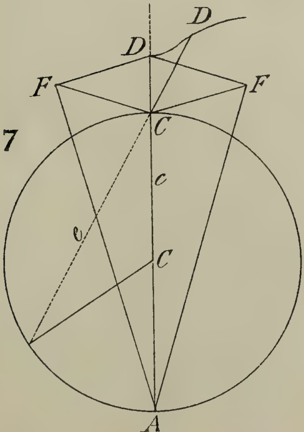
5



6



7



25th April, 1882.

The President, ROBERT LLOYD PATTERSON, Esq., in the Chair.

A Paper was read by Rev. ROBERT WORKMAN, on

FORTS, HOUSES, AND CHURCHES OF ANCIENT IRELAND.

Mr. WORKMAN began by directing attention to the raths, duns, and caishels as being from their number and antiquity among the most important monuments of our country. These forts consisted of an earthen or loose stone dyke, enclosing a circular space. The dyke originally had a height of from eight to twelve feet. Beehive-shaped huts have been found in several of these encampments, and there is often an underground passage or chamber beneath them. These were doubtless the fenced camps of the Irish tribes; the chief and his immediate followers harboured within them, and in time of war they sheltered the clan and the cattle against a sudden attack. Earth forts were the strong places of the Irish from the most remote antiquity till the end of the thirteenth century, but when the English appeared upon the scene they lost their importance, as being unsuitable to the new modes of warfare then introduced.

Mr. Workman then referred to ancient houses as throwing light upon the condition of the country, since a few Irish houses with their furniture would enable us to know what were the habits and the civilisation of the people. Here, however, was the difficulty, for Irish houses were of such frail materials that they have perished. Mr. Workman held that the body of the common people in the interior of the country had scarcely any-

thing worthy of the name of houses towards the close of the sixteenth century. The English penetrating to the centre of Ulster, in 1542 found it a jungle. Tyrone's country is described as "not containing a single castell, nor yet one walled town; nothing but bogs of water, so that it would be hard to have it inhabited." Sir Fulke Conway, one of the principal settlers in King James's Plantation of Ulster wrote home saying: "This part of ye country is bleak and desolate as though foot of man had never penetrated the wilderness." The English Government described Derry as we would now describe the most remote and unappropriated colonial fields; and English captains, finding no spoil of war, complained that "the Irish in the interior lived without houses, and that O'Neill kept his people and cattle in such wild places that the English could not reach them, nor even certainly know their whereabouts." Traps to catch wolves were part of the provision made for Ireland by Cromwell's Government; and in the year 1683 a considerable quantity of fox and other skins was exported from Belfast to England, Holland, and the Baltic.

Mr. Workman showed that Irish houses were built of wood, wattles, and mud, and in some cases of loose stones, till long after the English invasion. Tara Hill, which was the abode of kings and chieftains, and a place where the most substantial buildings might be expected, had nothing but houses of wood and clay, and there is no evidence that mortar was ever used in pagan times. Irish houses were beehive-shaped, probably because wattles and clay were most readily fashioned into a house of such a form.

Mr. Workman here exhibited a *fac-simile* of a map of Carrickfergus in Elizabeth's time, in which, side by side with the castelled houses of the English, the primeval cabins of the Irishry were depicted. These huts were half globes, without eaves or chimney, a single aperture serving for door and window. The reader also showed a sketch of a stone house of similar form from Arran, in Galway Bay, which is believed to date from pagan times, and gave it as his opinion that these were the dwellings of a people who lived in the open air, and were stran-

gers to sedentary pursuits. Cattle-tending and hunting were their constant occupations. Forays and skirmishes with neighbouring clans were the scenes in which the men delighted to display their strength and skill.

In referring to the architecture of early Christian times, Mr. Workman said that the monastery characterised the Irish Christianity of the sixth century. The primitive Irish monasteries were very practical institutions. Having no missionary societies to aid them, the brethren supported themselves cultivating the soil, rearing cattle and fowl, and fishing the loughs and seas. Their spiritual work was the instruction of Christian converts and the training of young evangelists. Division of labour developed the gifts of individuals: the ready writer copied manuscripts, the artist illuminated them, and the man skilled in metals wrought the croziers and relic shrines which display such care and taste.

There is ground for considering that these monastic institutions were peculiarly adapted to the state of the country. Ireland was peopled by a number of independent tribes continually at war. Plunder and slaughter were the serious business of the chieftains and the work they demanded of their followers. How were Christian converts to live in societies where they must follow these practices? And how, on the other hand, could they exist outside the protection which the clan afforded to its members? Both missionaries and converts required the protection and encouragement which the monastic community afforded. The monks adapted themselves to the customs of the people, and adopted the rath as a defensive enclosure of the space on which they erected their chapel and cells; and the sole distinction of the monastic rath is the presence of a chapel of rectangular form, in a few instances cemented with mortar. The monks dwelt in globular cells, armed similarly to those already described. Thus the ecclesiastical establishment was a half military camp down to the twelfth century, for the Irish Church was truly a Church militant, and her chapels and houses had need of all the protection the rath could afford. As to materials, Mr. Workman showed that Irish ecclesiastical

bnildings were commonly recognised as of a peculiar construction, which had come to be designated as the Scotic manner; that one peculiarity of the Scotic method consisted in the materials employed, which were not stone and mortar, but wood and earth; and that a quadrangular building was a great novelty in early times. Mr. Workman held the small solid-roofed church to be the earliest type of ecclesiastical building. Its average size was sixteen feet by ten feet; it was destitute of ornament, and of a stern simplicity. It had one door and one window, and in it the distinction between nave and chancel is still unknown. There is an extreme rudeness of form, for many of these churches are built of dry stone, without cement of any kind.

Mr. Workman undertook to show the gradual transition from the round cell of pagan times to this primitive chapel, and exhibited drawings of chapels in which the corners had been rounded off so as to make the ground plan approach the circular form, and the walls had been made to converge from the very ground till they met in an arching roof. He held that in such instances we actually find the pagan cell passing over and being transformed into the rectangular perpendicular-walled chapel. We have thus pushed back our inquiry till we touch pagan times, and cannot doubt that we have in these single chambered churches the primitive type of Irish Christian sanctuary.

In regard to the round towers, Mr. Workman held it had been established that they were belfries and places of refuge, and believed they were erected about the tenth and eleventh centuries. Endeavouring to show how the idea of the round tower had originated, he pointed out that the peculiar features which distinguished it, its circular form and solid pointed roof, lay ready to hand, and were familiar in the monastic rath. The beehive cell suggested the round form, and the solid pointed roof of the primitive chapel only required to be raised in the air and placed upon the summit of the lengthened column. When the ravages of the Danes made them feel the need of a temporary defence, it was the most natural thing in the world that, taking the circular foundation of a cell as the ground plan,

they should build upon it high enough into the air to form a comparatively safe refuge and storehouse against their assailants. The round tower is, therefore, to be regarded as a genuine original Irish development from architectural forms already present.

Mr. Workman considered that the civilization of Ireland was almost entirely an ecclesiastical civilization. The Church and the world were in contact, but they did not blend. During the period when Ireland was looked on as an island of saints and scholars, and Irish monks were evangelising the barbarous hordes abroad, there does not appear to have been any corresponding manifestation of culture amongst Irish laics. Irish secular life has left no trace behind, and almost all remains, architectural or artistic, are ecclesiastical remains. Irish Church antiquities, however, do possess an interest all their own—the primitive stone-roofed churches, as substantial as if they had been hewn out of the rock; the isolated pillar tower, which in other days sheltered the monks from the furious Northmen, and which now stands grey and solitary and mysterious, the most prominent object upon the plain; the crosses, which commemorate the early founders of Christianity. These interesting memorials are only to be found in our country and in those parts of Scotland which came under the influence of Irish Christianity.

BELFAST

Natural History & Philosophical Society.

Officers and Council of Management for 1882-83.

President.

ROBERT LLOYD PATTERSON, Esq., J.P.

Vice-Presidents.

J. ANDERSON, Esq., J.P., F.G.S.
ROBERT MacADAM, Esq.
Prof. J. D. EVERETT, M.A., F.R.S.
Prof. R. O. CUNNINGHAM, M.D.

Secretary.

CHARLES WORKMAN, Esq., M.D.

Treasurer.

JOHN BROWN, Esq.

Librarian.

THOMAS WORKMAN, Esq.

Members of Council.

JOSEPH J. MURPHY, Esq., F.G.S.
JOSEPH WRIGHT, Esq., F.G.S.
WM. SWANSTON, Esq., F.G.S.
JOHN PURSER, Esq., M.A.
ROBERT YOUNG, Esq., C.E.
W. H. PATTERSON, Esq., M.R.I.A.
E. A. LETTS, Esq., Ph.D., E.R.S.E.

SHAREHOLDERS.

[**Denotes holders of three or more Shares.*]

Allen, W. J. C., J.P., Faunoran, Greenisland.
Andrews, Michael (Representatives of), Ardoyne, Belfast.
Andrews, Thomas, M.D., F.R.S., &c., Fortwilliam Park, do.
Andrews, Samuel, J.P., Victoria Street, do.
Archer, S., J.P. (Representatives of), Wellington Place, do.
Anderson, John, J.P., F.G.S., Hillbrook, Holywood.
*Alexander, James, J.P. (Representatives of), Holywood.

*Bateson, Sir Thomas, Bart., M.P., J.P., D.L., Belvoir Park, Belfast.	
*Batt, Thomas G. (Representatives of),	Belfast.
Bland, Rev. W., J.P. (Representatives of).	
Bottomley, Henry H., Ulster Street,	Belfast.
*Bottomley, William, J.P.,	do.
Brett, C. H., Chichester Street,	do.
Bristow, James R., Northern Bank,	do.
Barbour, James, Falls Foundry,	do.
Boyd, William, Blackstaff Mill,	do.
Boyd, W. S., Donegall Quay,	do.
Brown, John Shaw, J.P., Bedford Street,	do.
Brown, John, Bedford Street,	do.
Burden, Henry, M.D., Alfred Street,	do.
Burnett, John R., Gamble Street,	do.
*Campbell, James (Representatives of).	
Campbell, John, Lennoxvale.	Belfast.
Connor, Charles C., White Linen Hall,	do.
Carlisle, James, J.P., Donegall Street,	do.
Carson, John, Church Lane,	do.
Charley, John (Representatives of),	do.
*Charley John (Representatives of), Finaghy,	do.
*Clermont, Lord, Ravensdale, Park, Newry.	
Coates, Victor, Rathmore, Dunmurry.	
*Charters, John (Representatives of).	
Crawford, William, Calender Street,	Belfast.
Cuming, James, M.D., Wellington Place,	do.
Combe, James, J.P. (Representatives of).	
Connor, James (Reps. of), Great George's Street,	Belfast.
Calwell, Alexander, McD., College Square North,	do.
Cunningham, Robert O., M.D., F.L.S., Queen's College,	do.
Clarke, Edward H., Elmwood,	do.
Darbishire, James M., Lombard Street,	do.
*Donegall, Marquis of, K.P., &c., &c., London.	

Drennan, Dr., Chichester Street, Belfast.
*Drummond, Dr. James L. (Representatives of), do.
Duffin, Charles, J.P., Waring Street, do.
Dunville, William, J.P. (Representatives of), Calender St., do.
*Downshire, Marquis of, Hillsborough Castle, Hillsborough.
Dixon, Thomas S., York Street, Belfast.
Emerson, William, Donegall Quay, do.
Everett, J. D., M.A., D.C.L., F.R.S., Queen's College, do.
Ewart, William, J.P., M.P., Bedford Street, do.
Ewart, W. Quartus, Bedford Street, do.

*Fenton, Samuel G., J.P. (Representatives of), do.
Ferguson, Henry, M.D., Fisherwick Place, do.
Forsythe, R. H., Holywood.
Finlay, William Laird, Windsor, Belfast.
Finlay, William Laird, jun., 16, Corporation Street do.
Fuller, Professor George, Queen's College, do.
Fagan, John, F.R.C.S.I., Glengall Place, do.

Garrett, Thomas, Gamble Street, do.
*Getty, Edmund (Representatives of), do.
Girdwood, H. Mercer, Broughton Maxwell, Manchester.
Gordon, Alexander, M.D., Howard Street, Belfast.
Gordon, R. F., J.P., D.L., Florida Manor, Killinchy.
*Grainger, Rev. John, D.D., Broughshane, Ballymena.
Gray, Robt. (Representatives of), College Square North, Belfast.
Gordon, Robert W., Falls Road, do.
Greer, Thomas, J.P., M.P., Seapark, Carrickfergus.
Gray, William, C.E., M.R.I.A., Mount Charles, Belfast.

Hogg, John, Academy Street, do.
*Hamilton, Hill, J.P. (Representatives of), Mount Vernon, do.
Hancock, John, J.P., Lurgan.
Henderson, Robert (Representatives of), High Street, Belfast.
*Henry, Alexander, Manchester.
*Herdman, John (Representatives of), College Sq. North, Belfast.

Hind, James, Durham Street,	Belfast.
Hind, John, J.P., Durham Street,	do.
Hind, John, jun., College Street South,	do.
Heyn, James, A.M., Ulster Chambers, Waring Street,	do.
*Houston, John B., J.P., D.L., Orangefield,	do.
Herdman, John, J.P., Carricklee House, Strabane.	
Hamilton, Sir James, J.P. (Reps. of), Corporation St.	Belfast.
Harland, Edward J., J.P., Queen's Island,	do.
Hodges, John F., M.D., F.C.S., Queen's College,	do.
Hyndman, Hugh, LL.B., Waring Street,	do.
Henderson, W. D. (Representatives of), Victoria Street,	do.
Henderson, James Alexander, J.P., Donegall Street,	do.
Holford, T. & A., Dorsetshire (Cern Abbas).	
Jackson, Thomas, C.E., Corn Market,	Belfast.
Jackson, W. R., Corn Market,	do.
Jaffé, John, Donegall Square South,	do.
Jaffé, Otto, Donegall Square South,	do.
*Johnson, Sir William G., J.P., D.L., College Sq. North,	do.
Johnston, Samuel A., Jennymount Mill,	do.
Johnston, David W., Jennymount Mill,	do.
Kennedy, James, Falls Road,	do.
Keegan, John J., High Street,	do.
*Kinghan, Rev. John, Deaf and Dumb Institution,	do.
Lanyon, Sir Charles, J.P., The Abbey, Whiteabbey.	
Lepper, F. R., Ulster Bank,	Belfast.
Lakin, Mrs. John, Tamworth.	
Lamb, William W., Divis View,	Belfast
Letts, Professor E. A., Queen's College,	do.
Lytle, David B., Victoria Street,	do.
*Macrory, Adam J. (Representatives of), Ulster Chambers,	do.
Mitchell, W. C., J.P., Tomb Street,	do.
*Mitchell, George T. (Representatives of),	do.

Montgomery, Thomas, J.P., Ballydrain, Belfast.
Moore, James, J.P., Dalchoolin, Craigavad.
*Mulholland, Andrew, J.P., D.L. (Representatives of), Belfast.
Mulholland, J., J.P., D.L., M.P., Ballywalter Park, Ballywalter.
Mullan, William, J.P., Victoria Street, Belfast.
Murney, Henry, J.P., M.D., Donegall Square East, do.
Musgrave, James, J.P., Ann Street, do.
Murray, Robert (Representatives of), Arthur Street, do.
*Murphy, Joseph John, F.G.S., Old Forge, Dunmurry.
*Murphy, Isaac James, Glenburn, do.
Musgrave, Henry, Ann Street, Belfast.
Musgrave, Edgar, Ann Street, do.
Moore, James, Donegall Place, do.
*M'Calmont, Robert, London.
*M'Cammon, Thomas, Dublin.
M'Clure, Sir Thomas, Bart., V.L., M.P., J.P. Belmont, Belfast.
M'Cance, Finlay, J.P., Suffolk, Dunmurry.
*M'Cance, J. W. S. (Representatives of), Suffolk, Dunmurry.
*M'Cracken, Francis (Representatives of), Donegall St., Belfast.
MacAdam, Robert, College Square East, do.
MacIlwaine, Mrs. Jane, do.
MacIlwaine, Rev. Canon, D.D., M.R.I.A., Netherville Terrace, Belfast.
*MacLaine, Alex., Queen's Elms, Belfast.
M'Gee, John G., High Street, do.

Neill, John R., Queen's Arcade, do.

Patterson, E. Forbes, High Street, do.
Patterson, Mrs. M. E., Ardmore Terrace, Holywood, do.
Pim, Edward W., High Street, do.
Pim, George C., Corporation Street, (Representatives of), do.
*Pirrie, John M., M.D. (Representatives of), do.
Purdon, Charles D., M.D. (Reps. of), Wellington Place, do.
Purdon, Thomas Henry, M.D., do. do.
Patterson, William R., Lower Crescent, do.

Patterson, R. Lloyd, J.P., Corporation Street,	Belfast.
Patterson, William H., M.R.I.A., High Street,	do.
Purser, Professor John, M.A., Queen's College,	do.
Porter, Rev. J. Scott (Representatives of),	do.
Patterson, Richard, High Street,	do.
Patterson, David C., Corporation Street,	do.
Riddell, William, Ann Street,	do.
Rowan, John, York Street,	do.
Ritchie, W. B., M.D., J.P., The Grove,	do.
Ross, William A., J.P., Clonard, Falls Road,	do.
Rea, John Henry, M.D., Great Victoria Street,	do
Robertson, William, J.P., Bank Buildings,	do.
Robinson, John, York Street,	do.
Simms, William (Reps. of), White Linen Hall,	do.
Sinclair, Thomas, M.A., J.P., Tomb Street,	do.
Suffern, John, Windsor,	do.
Suffern, William, Windsor,	do.
Steen, Dr. Robert, Ph.D., Academical Institution,	do.
Smyth, John, jun., M.A., C.E., Milltown, Banbridge.	
Smith, F. Chaloner, Sandymount.	
Swanston, William, F.G.S., King Street,	Belfast.
*Tennent, R. J., J.P., D.L. (Representatives of), Rushpark,	do.
*Tennent, Robert (Representatives of), Rushpark,	do.
Thompson, Robert, J.P., Fortwilliam Park,	do.
Thomson, Charles, College Gardens,	do.
*Thompson, James, J.P., Macedon, Whiteabbey.	
*Thompson, Nathaniel (Representatives of).	
*Thompson, William (Representatives of),	Belfast.
*Turnley, John (Representatives of),	do.
Torrens, James, J.P., Wellington Place,	do.
Valentine, James W., Custom House Square,	do.
Valentine, Thomas, J.P., The Moat, Strandtown,	do.

Walkington, Thomas R., Waring Street,	Belfast.
Workman, William, Corporation Street,	do.
Workman, Rev. R., Newtownbreda.	
Wilson, John K., Donegall Street,	do.
*Wilson, Robert M.	
*Workman, Thomas, Bedford Street,	Belfast.
Wallace, James, Ulster Bank,	do.
Ward, Fras. D., J.P., Bankmore,	do.
Wright, Joseph, F.G.S., Donegall Street,	do.
Workman, Charles, M.D., Balmoral Terrace,	do.
Workman, Rev. R., Glastry, Kirkcubbin.	
Walkington, D. B., Windsor,	do.
Young, Robert, C.E., Donegall Square East,	do.
Young, Robert M., Donegall Square East,	do.

HONORARY MEMBERS.

Robinson, Hugh, Donegall Street,	Belfast.
Stewart, Samuel A., F.L.S., North Street,	do.
Tate, Professor Ralph, F.G.S., Adelaide, South Australia.	

ANNUAL GUINEA SUBSCRIBERS.

Barber, J., County Down Railway,	Belfast.
Bruce, James, J.P., Calender Street,	do.
Bulloch, A., Donegall Square South,	do.
Corry, James P., J.P., M.P., Dunraven, Windsor,	do.
Craig, James, J.P., Calender Street,	do.
Corry, Thomas H., Benvue, Malone,	do.
Collier, W. F., LL.D., Belfast Academy,	do.
Carr, James, Ulster Bank,	do.
Dinnen, John, Chichester Street,	do.
Dunville, Robert G., D.L., J.P., Calender Street,	do.
Finlay, Alexander, Ann Street,	do.
Glass, James, Bedford Street,	do.

Glover, G. T., Ballymacarrett,	Belfast.
Graham, O. B., J.P., York Street,	do.
Liversedge, H. J., Lagan Foundry,	do.
Loewenthal, J., Linenhall Street,	do.
Lynn, William H., C.E., Calender Street,	do.
Matier, Henry, J.P., Clarence Place,	do.
Mulholland, J. R. T., J.P.,	do.
M'Auliffe, George, J.P., Calender Street,	do.
Oakman, Nicholas, Prospect Terrace,	do.
Pring, Richard W., Corn Market,	do.
Redfern, Peter, M.D., Professor Queen's College,	do.
Reade, Robert H., York Street,	do.
Seeds, William, Corn Market,	do.
Taylor, David, J.P., Windsor,	do.
Tate, Alexander, C.E., Queen's Elms,	do.
Taylor, John Arnott, M.A., Bridge Street,	do.
Watt, R., Donegall Place,	do.
Wolff, G. W., Queen's Island,	do.
Wilson, James, Skipper Street,	do.
Ward, John, F.G.S., Lennoxvale,	do.
Ward, Marcus J., Bankmore,	do.

The Belfast Natural History and Philosophical Society, for the Year ending 1st May, 1882, in Account with Treasurer.

Dr. — EXPENDITURE.

1881.				
Aug.	—To Cash paid Insurances . ..	£11	5	0
Nov.	,, ,, through Librarian ..	2	0	8
,,	,, ,, Rent till 1st Feb., 1882	25	0	0
,,	,, ,, A. Mayne, Printing ..	23	13	0
,,	,, ,, A. O'D. Taylor ..	6	13	2
,,	,, ,, S. A. Stewart, Salary till 1st April ..	43	15	0
,,	,, ,, W. Darragh, Salary till 1st May, ...	48	0	0
1882.				
Feb.	,, ,, Wm. M'Cammond, Contractor, Drains, &c.,	21	15	10
May	,, ,, Robert Murray & Co., Platform, &c. ..	5	5	0
,,	,, ,, Coals, Coke, and Gas, ..	14	4	4
,,	,, ,, Easter Expenses £7 7s 5d, Collecting Subscriptions £6 17s 6d	14	4	11
,,	,, ,, Sundry Accounts, including Postages £1 9s 10d, Advertising £7 10s 8d, &c.	14	5	1
,,	To Balance in Treasurer's hands ..	0	15	6
		£230	17	6

Cr. — RECEIPTS.

1881.				
May 1	—By Balance in hands	£38	3	10
,,	,, Subscriptions in Arrear, and Transfer Fees	3	15	6
Nov.	,, Interest on York Street Loan ..	18	12	1
1882.				
Jan.	,, New Shares taken up, 1880 ..	21	0	6
May	,, Subscriptions in Arrear, and Donation through Librarian	3	5	0
,,	,, Naturalists' Field Club Contribution	5	5	0
,,	,, Subscriptions for year ending Nov., 1881	91	15	0
,,	,, Entrance Fees at Door, till 1st May	17	17	6
,,	,, ,, ,, Easter Monday	31	3	1
		£230	17	6
1882.				
May 1	—By Balance	0	15	6

Examined and found correct,
June 3rd, 1882.

WM. H. PATTERSON, } *Auditors.*
SAMUEL ANDREWS, }

JOHN ANDERSON, *Hon. Treasurer.*

p. 12

Report and Proceedings

OF THE

BELFAST

Natural History and Philosophical Society,

FOR THE

SESSION 1882-83.

BELFAST:
PRINTED BY ALEXANDER MAYNE, CORPORATION STREET.
(PRINTER TO THE QUEEN'S COLLEGE.)

1883.

Report and Proceedings

OF THE

BELFAST

Natural History and Philosophical Society,

FOR THE

SESSION 1882-83.

BELFAST:
PRINTED BY ALEXANDER MAYNE, CORPORATION STREET.
(PRINTER TO THE QUEEN'S COLLEGE.)

1883.

CONTENTS.

Belfast Natural History and Philosophical Society.

ESTABLISHED 1821.

SHAREHOLDERS.

1 Share in the Society costs £7.
2 Shares „ „ cost £14.
3 Shares „ „ cost £21.

The proprietor of 1 Share pays 10s. per annum ; the proprietor of 2 Shares pays 5s. per annum ; the proprietor of three or more Shares stands exempt from further payment.

Shareholders only are eligible for election on the Council of Management.

MEMBERS.

There are two classes, Ordinary Members, who are expected to read Papers, and Visiting Members, who, by joining under the latter title, are understood to intimate that they do not wish to read Papers. The Session for Lectures extends from November in one year till May in the succeeding one. Members, Ordinary or Visiting, pay £1 1s. per annum, due first November in each year.

PRIVILEGES.

Each Shareholder and Member has the right of personal attendance at all meetings of the Society, and of admitting a friend thereto ; also of access to the Museum for himself and family, with the privilege of granting admission orders for inspecting the collections to any friend not residing in Belfast.

Any further information can be obtained by application to the Secretary. It is requested that all accounts due by the Society be sent to the Treasurer.

The Museum, College Square North, is open daily from 12 till 4 o'clock. Admission for Strangers, 6d. each. The Curator is in constant attendance, and will take charge of any Donation kindly left for the Museum or Library.

REPORT OF THE COUNCIL

TO THE

ANNUAL MEETING OF THE SOCIETY,

Held at the Museum, 19th June, 1883.

The Council for the year 1882-3, appointed by the Shareholders at their annual Meeting, on the 14th June, 1882, desires to lay before them its Report on their property, and the other interests of the Society.

The Society's Museum and collections are in very good condition; and during the past year your curators, with the assistance of some of the members, have been able to get much further work done in the way of re-arranging and labelling the specimens in certain departments. A number of specimens have been received from various friends during the year, and have been added to the collections. A list of these additions will be given at the end of this Report.

On Easter Monday, the number of visitors to the Museum was very large, the charge being as usual, two-pence for adults and a penny for children. The several rooms were specially arranged for such visitors, and these showed much interest in the collections displayed for their examination.

Seven ordinary meetings have been held during the late session, at which nine papers have been read by members of our Society, as follows:—

The first meeting was held on the 7th November, 1882, when a paper was read by Mr. Thos. Workman on "A recent visit to Brazil." The second meeting was held on the 5th Dec., when (1st) a paper was read by Mr. Joseph John Murphy

on "Deltas," and (2nd) a paper by Mr. John Brown on "The Atmospheric feeding of plants." The third meeting was held on the 30th January, 1883, when a paper was read by Mr. Wm. Gray, M.R.I.A., entitled "Notes on House Drainage." The fourth meeting was held on the 6th February, when a paper was read by Mr. S. A. Stewart, F.S.B.E., on "Rathlin Island, with notes on its Natural History and Antiquities;" also a paper by Mr. W. H. Patterson, M.R.I.A., on "Etching on Copper." The fifth and sixth meetings were held on the 27th February and the 6th March, when two lectures were delivered by Professor Letts, on "The Spectroscope and its Uses." These lectures were illustrated by experiments, with the assistance of the electric arc. They were very well attended, the large lecture-room being crowded to inconvenience on both occasions. The seventh meeting was held on the 10th April, when a paper was read by the Rev. Robert Workman, Newtownbreda, on "The Warfare of Ancient Ireland."

In addition to these ordinary meetings, two special meetings were held under the auspices of our Society, in St. George's Hall, on the 24th and 26th April, when Mr. Richard A. Proctor delivered two lectures—the first on "The birth and death of Worlds," and the second on "The Sun: the Ruler, Light, and Life of the Solar System." These lectures proved highly successful, being very largely attended, and giving the greatest pleasure and instruction to the audiences.

On the occasion of all the above-mentioned meetings, special as well as ordinary, except one, the chair was occupied by the President of the Society, Mr. Robert Lloyd Patterson. The exception referred to was the meeting of the 30th January, when the Rev. Canon Grainger presided. At all the meetings the attendance was above the average of recent years, and the Council feel that they may congratulate the shareholders and members generally on a distinctly increasing public interest in our proceedings. To assist in making the meetings more social and attractive, and also to render attendance more convenient for the increasing number of our members who reside in the country, the Council during the past session

provided tea in the Museum on the evenings of meeting for the members and their friends. The thanks of the Council are due to those who so kindly aided in giving effect to this new arrangement, which has entirely come up to the expectation of those who suggested it. The ordinary hour of meeting has been changed from 8 p.m. to 7.30 p.m., as it was found this would suit most of the members better.

Your Council now retires from office, and this meeting will be asked to elect fifteen members to form a new Council in its stead. The members of the outgoing Council, being eligible, offer themselves for re-election.

The Report of the Treasurer stated that the balance against the Society was £15 7s. 6d., and as they had commenced the year with 15s. in hand, the income had been £16 3s. 0d. less this year than last year. Some outstanding accounts still due left the deficit about £20.

The Belfast Natural History and Philosophical Society, in account with Treasurer.

Dr. For the Year ending 1st May, 1883. **Cr.**

1882. EXPENDITURE.	£	s.	d.
—To Cash paid Insurance	£7	18	9
,, ,, Repairs and Renewals, New Range, Timber, &c. ..	10	8	10
,, ,, Advertising, Printing, Stationery, &c.	5	8	0
,, ,, Postage	2	15	5
,, ,, Printing Report	17	17	0
,, ,, Rent till 1st May	25	0	0
,, ,, Collecting Subscriptions ..	6	7	0
,, ,, Easter Monday Expenses ..	7	10	6
,, ,, Coal, Coke, and Gas ..	12	0	4
,, ,, Small Accounts	3	0	8
,, ,, Wm. Darragh, Salary till 1st May	48	0	0
,, ,, S. A. Stewart, Salary till 1st May	43	0	0
	£189	6	6
—To Balance	£15	7	6

1882. RECEIPTS.	£	s.	d.
—By Balance in hands	£0	15	6
,, Contribution from Engineers' Association, for 1881-82	4	3	0
,, Interest on York Street Loan	19	9	2
,, Subscriptions in Arrears	2	5	0
,, Transfer Fees	0	7	0
,, Subscriptions for year ending November, 1882	86	14	0
,, Contributions from Naturalists' Field Club	5	5	0
,, Entrance Fees at door till 1st May ..	16	15	3
,, Entrance Fees at door, Easter Monday	38	5	1
,, Balance due Treasurer	15	7	6
	£189	6	6

Examined and found correct, Wm. H. Patterson, Samuel Andrews, } *Auditors.*

J. Brown, *Hon. Treasurer.*

BELFAST
Natural History & Philosophical Society.

Officers and Council of Management for 1883-4.

President:

PROFESSOR CUNNINGHAM, M.D.

Vice-Presidents:

JOHN ANDERSON, Esq., F.G.S.
ROBERT MacADAM, Esq.
Prof. J. D. EVERETT, M.A., F.R.S.
THOMAS WORKMAN, Esq.

Treasurer:

JOHN BROWN, Esq.

Librarian:

THOMAS WORKMAN, Esq.

Secretary:

CHARLES WORKMAN, Esq., M.D.

Council:

PROFESSOR CUNNINGHAM, M.D.
JOHN ANDERSON, Esq., F.G.S.
ROBERT MacADAM, Esq.
PROFESSOR J. D. EVERETT, M.A., F.R.S.
THOMAS WORKMAN, Esq.
JOHN BROWN, Esq.
CHARLES WORKMAN, Esq., M.D.
PROFESSOR E. A. LETTS, Ph.D., F.R.S.E.
JOSEPH JOHN MURPHY, Esq., F.G.S.
ROBERT LLOYD PATTERSON, Esq.
WILLIAM H. PATTERSON, Esq., M.R.I.A.
PROFESSOR PURSER, M.A.
WILLIAM SWANSTON, Esq., F.G.S.
JOSEPH WRIGHT, Esq., F.G.S.
ROBERT YOUNG, Esq., C.E.

LIST OF DONATIONS TO THE MUSEUM, 1882-83.

From John Anderson, J.P., F.G.S.

Sundry ancient papers, being petitions and statements concerning the woollen and linen manufactures.

From Miss Benn, Fortwilliam Park.

Several specimens of ancient Peruvian pottery.

From Captain Robert Campbell, Dundee.

Two Indian weapons; vertebral column of a shark; skin of a peacock pheasant; skull of an Indian tiger; antlers of an Indian deer (Cervis rusa), three specimens; skull and horns of a Gyal.

From Mr. J. S. Cathcart, Belfast.

Two Indian idols of bronze; snuff-box carved in turtle's shell; parasol handle finely carved in ivory; thirteen coins; iron ball found in a field in County Derry.

From Mr. M'Dowell, Loughmourne.

Portion of an ancient canoe, and a rubbing stone, found at the Loughmourne crannoges.

From Mr. W. Swanston, F.G.S., Belfast.

A pair of Indian sandals; a cinerary urn.

From Mr. S. A. Stewart, Belfast.

Several rude stone implements, found by him in Rathlin Island.

From Mr. Thomas Workman, Belfast.

Three stone arrowheads from Oregon.

LIST OF BOOKS RECEIVED DURING THE YEAR.

ADELAIDE.—Transactions and Report of the Royal Society of South Australia. Vol. 4, 1882. *The Society.*

BELFAST.—Belfast Naturalists' Field Club Annual Report, 1882. *The Society.*

BREMEN.—Abhandlungen vom Naturwissenchaftlichen Verein. Band 8, Heft 1, 1883. *The Society.*

BATH.—Proceedings of the Bath Natural History and Antiquarian Field Club. Vol. 5, 1882. *The Society.*

BELOIT, Wisconsin, U.S.A.—Survey of the Geology of Wisconsin, 1873—79. Vol. 3, Atlas of Maps, 1880. *The Survey.*

BERLIN. — Verhandlungen der Gesellschaft fur Erdkunde. Vol. 1, 2, 3, 4, 8, 9, 10, 1882. *The Society.*

BOLOGNA.—Accademia delle Scienze Rendiconto delle sessioni, 1881-82 *The Society.*

BOSTON, U.S.A.—Science Observer. Vol. 4, nos. 1, 2, 5, 6. *The Editor.*

Proceedings of the Boston Society of Natural History. Vol. 20, part 4; vol. 21, parts 1, 2, and 3, 1881. *The Society.*

BRIGHTON.—Annual Report of the Brighton and Sussex Natural History Society for year ending 30th September, 1882. *The Society.*

BRUSSELS.—Société Entomologique de Belgique, Comptes-Rendus, Series 3, nos. 17, 18, 19, 20, and 21, 1882. *The Society.*

BRUSSELS.—Bulletin de la Société Royale de Botanique de Belgique. Vol. 21, 1883. *The Society.*

Société Royale Malacologique de Belgique, proces-verbal, 1883. *The Society.*

CALCUTTA.—Memoirs of the Geological Survey of India. Vol. 19, part 1 (Palaeontologica Indica), series 10; vol. 2, parts 1 and 2; series 14, vol. 1, part 3 (*Fas.* 2 records); vol. 15, parts 1 and 3. *The Survey.*

CARDIFF.—Cardiff Naturalist Society. Vol. 1 for 1881. *The Society.*

CASSEL.—Botanisches Centralblatt. 3rd year, Book 10, No. 10, 1882. *The Society.*

CHERBURG.—Société des Sciences Naturelles. Vol. 23, series 3; vol. 3, 1881. *The Society.*

CINCINNATI, U.S.A.—Ohio Mechanics' Institute, Scientific Proceedings, 1882. Vol. 1, nos. 2, 3. *The Society.*

DANZIG.—Schriften der Naturforschenden Gesellschaft. Vol. 15, part 3, 4, 1882-83. *The Society.*

DAVENPORT, U.S.A.—Proceedings of the Academy of Natural Sciences. Vol. 3, part 1, 2, 1882. *The Society.*

DUBLIN.—Transactions of the Royal Dublin Society. Vol. 1, series 2, 15, 16, parts 17 and 18.

Do. Aquatic Carnivorous Coleoptera, by Dr. D. Sharp.

Scientific Proceedings. Vol. 3, part 5, 1882. *The Society.*

EALING.—Microscopical Natural History Club Conversazioni, 1880, 1881, and 1882. *The Society.*

EDINBURGH.—Royal Society of Edinburgh, Proceedings of. Vol. 11, No. 108, series 1880-81. *The Society.*

GENOA.—Giornale della Societa di Letture Conversazionie Scientifiche di Genoa. Vol. 7, parts 5, 6, 7, and 8, (*Fasc.*), parts 1, 2, and 3. *The Society.*

Giessen.—Oberhessischen Gesselleschaft for Natur- und Heilkunde, 21st Report, 1882. *The Society.*

Glasgow.—Proceedings of the Natural History Society, 1882. *The Society.*

Gorlitz.—Jahresbericht de Naturforschenden Gesellschaft, 1880-81. *The Society.*

Hamburg-Altona.—Abhandlungen aus dem Gebiete der Naturwissenschaften vom Naturwissenschaftlichen Verein Vol. 7, part 2, Verhandlungen new series 6, 1882. *The Society.*

Harvard, U.S.A.—Bulletin of the Museum of Comparative Zoology. Vol. 9, parts 6, 7, and 8; vol. 10, parts 1, 2, 3, 4, Annual Report of the Curator of the Museum, 1882. *The Society.*

Kolozevart.—Magayr Novenytain Lapok. Vol. 6, Flora Europaea fragmentum auctore Augusto Grisebach, 1882. *The Society.*

Lausanne.—Bulletin de la Société vaudoise des Sciences Naturelles. 2nd series, vol. 18, nos. 87, 88, 1882. *The Society.*

Leipzig.—Sitzungsberichte der Naturforschenden Gesellschaft, 1881. *The Society.*

Do. do. 9th year, 1882, 1883. *The Society.*

London.—Proceedings of the Zoological Society. Index, 1871, 1880. Parts 1, 2, and 3, 1882. *The Society.*

Royal Microscopical Society, Journal of. Parts 29, 30, 31, 32, and 33. *The Society.*

Scientific Roll (Climate). Vol. 1, part 21, 1882. *The Editor.*

Withered Leaves, by J. W. Fisher. *The Author.*

Manchester.—Transactions of the Manchester Geological Society. Vols. 16, 17, parts 14, 15, 16, 17, 18, 1882; parts 3, 4, 5, 6, 7, 1883. *The Society.*

NEW YORK, U.S.A.—Bulletin of the American Geographical Society. Numbers 1, 2, 3, 4, 5.

Journal of same. Vol. 13, 1882. *The Society.*

Fingal's Cave, by F. C. Whitehouse, M.A. *The Author.*

PISA.—Atti Societa Toscana di Scienze Naturali. Vol. 3, Adunza, 12th March to 7th May, 1882. *The Society.*

ROME.—Atti della Accademia dei Lincei, 3rd Series. Vol. 6, parts 11, 12, and 14; vol. 7, parts 1 to 8, 1882. *The Society.*

ROTTERDAM.—Programme de la Societe Batave de, 1882. *The Society.*

SONDERSHAUSEN.— Irmsichia Korrespondenzblatt des Botanichen Vereins fur Thuringen. No. 1, 2, 3, 4, 5, and 12; Abhandlungen, parts 1 and 2, 1882. *The Society.*

TRIESTE.—Societa Adriatica di Scienze Naturali. Bollettino della Societa. No. 1, vol. 7, 1882. *The Society.*

VIENNA.—Verhandlungen der Kaizerlich Koniglichen Geologischen Riechsanstalt. Parts 1 to 11, and 12 to 16, 1882. *The Society.*

WARWICK.—Proceedings of Warwickshire Field Club, 1881. *The Club.*

Warwickshire Natural History and Archaeological Society. 46th Annual Report, 1882. *The Society.*

WASHINGTON, U.S.A.—Smithsonian Institute. List of Foreign Correspondents' Publications of the Bureau of Ettinology. Part 1, Report for 1880-1881. *The Society.*

Department of Agriculture. Report, 1880. *The Department.*

7th November, 1882.

The President, R. L. Patterson, Esq., in the Chair.

A Paper was read by Mr. Thomas Workman, on

A RECENT VISIT TO BRAZIL.

I arrived in Brazil on the 10th of February, 1881, and landed at Para, at the mouth of the Amazon. On my voyage out I was much struck with the brilliant colouring of the Physalia or Portuguese Man-of-war, and it appeared to me that it owes its safety partially, strange though it may appear, to the fact of its possessing bright colours. If, for instance, a bird were so foolish as to swoop down on one of these dwellers on the deep, it would simply burst the bubble, for the Physalia is nothing more, and have its labour for its pains, even possibly getting stung by some of the stinging filaments that float in the water from the lower side of the Physalia, and to that bird the bright colours would ever after act as a danger signal. Fish, no doubt, would fly from the Physalia's lovely colours, as it offers nothing in the way of food, and any near approach would certainly bring the too curious observer into unpleasant contact with the stinging threads streaming below. Dull and insignificant colours would always leave an uncertainty in the minds of birds and fish as to what the creature was, making it more liable, on that account, to be attacked ; thus, I think, can be seen the direct advantage and safety that brilliant colours give their possessor. All bright coloured Physaliae, having therefore fewer dangers,

would be more likely to survive and propagate ; and by the survival of the fittest they would continue in the struggle for existence, while the darker varieties disappeared.

I set out on Friday, 11th February, at six o'clock in the morning, for a stroll in the woods. The following are some of the notes taken at the time. "I have just beaten into my umbrella two curious insects, one of them allied to the Phasmidae or walking-leaf insects, black in colour, 2 inches long, the abdomen terminated by a round knob. The other insect I thought was one of the same class, but when I went to lift it, it emitted a silken thread, and I saw to my great delight that I had captured one those curious spiders belonging to the genus Ariamnes, first found by Doloschall in Java. I have got specimens of the same genus from Madagascar, but I think they have not been noted as having been found in South America.* This Spider moves very cautiously, drawing the hinder half of the abdomen along the ground. The abdomen and legs are of a light green colour ; the cephalothorax is darker ; the body is rather more than half an inch long ; the first pair of legs nearly as long as the body. It was living in a long grass-like plant growing on a species of laurel. Around me at the moment are numerous curious and beautiful plants, many of which seem familiar to me in greenhouses. At my feet is a plant with a banana-like leaf, but on a long stalk ; in the centre of the plant the flower, of a brilliant red, is shooting up. There is a cicada or some other insect that goes on Ping-ing-ing-ing like a fine wire vibrating and a liliputian triangle working at the same time ; there is also another insect making a somewhat similar sound, but not so mechanical or peculiar. Among the bushes I found an enormous spider's nest, or spidarium, if I can so coin the word, as it was the home of quite a large number of small and reddish brown coloured spiders probably allied to our Linyphia, at least so I think from the style of nest, a huge net resembling a bag, 3 feet in diameter at the bottom and 6 or 7 feet high, not an ordinary

* This is probably the Spider described by the Rev. O. P. Cambridge, M.A., in the Proceedings of the Zoological Society, London, for June, 1881, under the name of Ariamnes Attenuata.

nest of regular circular threads but zig-zag every way and of great strength, equal to about ordinary tissue paper. The spiders seemed to live at the bottom, as there were none at the upper part. Their cocoons were circular and about a quarter of an inch in diameter, fastened to the lower side of leaves, which were curved round so as to form a protection to them. Under these leaves the spiders were mostly congregated, 8 or 9 together, male and female. This is the only instance that I know of really gregarious spiders; though Mr. Darwin gives an instance in his 'Voyage of a Naturalist,' of a South American spider, a species of Epeira that makes its webs in close contiguity, and all attached to certain common lines of great length, and extending to all parts of the community; of which he says, 'These gregarious habits in so typical a genus as Epeira, present a singular case among insects which are so bloodthirsty and solitary, that even the sexes attack each other.' The spiders which I describe were more remarkable even than these, for they were living in a common nest, freely mixing, young and old.

I have just caught a handsome greenish beetle. It was moving slowly along the top of the grass-like plant mentioned before, also another curious spider, a male, formed so exactly like an ant that I mistook it for one, and would likely have thrown it away as an ant; only I am bottling any new species of ants that I see, and noticed that this one was differently coloured from other ants I had captured. It is light brown, with white spots on the abdomen; and ants, as is well known, have the body divided into three parts, joined by small petioles, the head forming the first part, the thorax the second, and the abdomen the third; while spiders have but two divisions of the body, the cephalothorax and the abdomen; however, this spider had a contraction in the abdomen making it appear in two. I also noted that this spider had not the restless, fearless habit of the ant, but crept under a leaf and hid there. In front of me there is a curious tree about 30 feet high, up the trunk of which, to the height of 8 or 9 feet, there are strong, sharp pointed spines, like nails on a telegraph post, only they have a large round base. Possibly they are to serve the same protective purpose. I have just come in

contact rather unpleasantly with a curious climbing plant, the stalk not thicker than fine cord ; it is exceedingly strong, so that it is not easily broken; all along this stalk are fine-recurved spines which hold on most tremendously, so that one is obliged to disentangle it carefully from one's clothes, otherwise the clothes would go first. The leaves, which are placed every 6 inches along the stem, are large, and resemble the convolvulus. I believe it is a palm, probably Desmoncus, figured in Bates. On the trunk of a tree I have picked up an enormous ant, a species of Dinoponera, about 1¼ inches long. They run with great rapidity. This is the first of them I have seen; I do not know if they bite, nor do I like to try. I have procured two more of the long sharp-tailed spiders, and find that these specimens hold the abdomen right off the ground ; indeed one of them carries it almost perpendicular ; these two are only half the size of the former one, they seem to hold the abdomen sharply bent at the spinnerets, which are situated about one fourth of the length from the front of abdomen. When hanging from their thread they often remain horizontal, being nearly equally balanced at the spinnerets, probably thereby more resembling a broken piece of grass.

5th December, 1882.

The President, R. L. Patterson, Esq., in the Chair.

A Paper was read by Joseph J. Murphy, Esq., F.G.S., on

DELTAS.

This paper was illustrated by a map of the Delta of the Nile.

A Delta was defined as consisting of one or more alluvial islands formed at the mouth of a river.

Running water is constantly wearing away the surface of the ground, and depositing elsewhere the material so carried away. The former of these actions is known as denudation, the latter as deposition. As the quantity of matter is unchangeable, the total amount of denudation effected by any river with its tributaries must be exactly equalled by the deposition effected by the same. This however is not always visible to the eye, because part of the deposition takes place at the bottom of the sea, beyond the mouth of the river. Denudation preponderates in the upper part of the valley of a river, and deposition in its lower part. In that part of a valley where there is more denudation than deposition, which is the state of things with which we are familiar, the slope of the ground is towards the stream ; but where deposition exceeds denudation, and where consequently the land on each side of the river consists of its own alluvium, the immediate banks of the river are the highest part of the country, and the slope of the ground is away from the river. This is well known to be the case along the lower Mississippi. The reason obviously is, that silt is deposited during inundations

most abundantly nearest to the river, on its immediate banks. The tendency of the banks to be raised in this way is greater in the climate of the Mississippi than in that of the Nile, because of the abundant vegetation of the former, which during inundations acts in some degree as a filter, detaining the mud and letting the water pass through.

The part of a river valley where there is more deposition than denudation may be called the alluvial part. In connexion with the fact that in the alluvial part of a valley, the banks of the river are generally higher than the rest of the country, is the fact that in such regions the stream often divides or bifurcates, without uniting again. The district lying between the arms of the river below its first or highest bifurcation, constitutes the delta. The delta of a river is of course included in that part of its valley where there is more deposition than denudation.

The writer mentioned having once stood on the Rothhorn mountain above the lake of Brientz in Switzerland, and seen as in a map the little delta formed by the Aar as it flows into the lake. It showed him the way in which deltas appear to be formed, which he believes to be as follows :—

It is well known that the quantity of silt which running water is able to carry in suspension, depends on the velocity of the current; and consequently when the velocity of a stream is checked by its flowing into the comparatively still water of a lake or sea, a great part of its silt is deposited. When the sea is not too deep, and the silt not removed by currents, an alluvial island is thus formed in front of the mouth of the river. By this island the stream of the river is divided into two, forming two mouths ; in front of each of these mouths another island is formed, producing further divisions ; and so on indefinitely.

It frequently happens that these islands are separated, not merely by river channels, but by extensive shallow lakes. Such lakes are characteristic of deltas ; of this kind are the Sea of Haarlem in Holland, now drained and converted into land, and Lake Pontchartrain near New Orleans. But Lake Mareotis, and the other lakes of the Egyptian delta, appear to be formed in quite a different way, by the action of wind and surf throwing

up sand-banks on the coast of a shallow sea, and thus cutting off the lakes from the sea.

POSTSCRIPT.

In the discussion that followed the reading of this paper, the opinion was advanced that an island cannot be thus formed in the mouth of a river; and that the bifurcation of a river must in every case be due to the river having at some past epoch burst its banks and formed a new channel without deserting the old one. This no doubt is possible, and probably common, in regions where the banks of the river, and the surface of the river, when full, are higher than the neighbouring country. But the possibility of an island being formed in the stream of a river appears to be proved by the instance, to mention only one, of the islands in the Rhine above Bingen. It is scarcely possible for any one to steam past those well known islands without feeling certain that they never were part of the mainland, but have been formed in the middle of the river by its alluvial deposit. Every bar at the mouth of a river may also be regarded as an incipient island so formed, or rather so forming, which has not yet risen above the water.

5th December, 1882.

The President, R. L. Patterson, Esq., in the Chair.

A Paper was read by Mr. John Brown, on

THE ATMOSPHERIC FEEDING OF PLANTS.

The reader referred to the fact that though much care was taken to provide plants with soil which should supply them with the various salts and other matters necessary to their growth, carbon, which forms so large a portion of organic tissues, could not be so supplied, since it is obtained from the air, where it exists in the form of carbon dioxide or carbonic acid gas. On considering the small quantity of this gas present in the air, representing only $1\frac{1}{2}$ part of carbon in 10,000 of air, it had occurred to him that plants must have considerable difficulty in obtainiug sufficient for their wants, and they would probably thrive better and grow faster in air atmosphere richer in carbon dioxide. To test this supposition six young pea plants were planted in pairs in three garden pots, covered with bell glasses, and all under like conditions, except that No. 1 bell glass had a current of carbon dioxide constantly passing into it; and under No. 3 was placed a dish containing solution of caustic potash, to absorb, if possible, all carbon dioxide in the air within it. No. 2 was left normal for comparison. In four days after the gas had been admitted there was a decided difference between Nos. 1 and 3. A week after this the difference was very striking. No. 1 had vigorous large dark leaves and stems half as thick again as No.

3, which was lanky and pale, with the edges of its leaves much serrated, as if the veins were growing on, but could not find food for the fleshy part of the leaf. No. 2 resembled No. 3 more than No. 1. Six days after this, or eighteen days after the gas had been applied, the plants were taken up, when the results given in the following table were obtained :—

	STEMS.		LONGEST LEAF.		WEIGHT.	
	Length.	Thickness.	Length.	Thickness.	Fresh.	Dry.
No. 1	14·25 in.	·128 in.	1·56 in.	·011 in.	148 grs.	19
„ 2	15·25 in.	·103 in.	1·07 in.	·006 in.	115·5	16·4
„ 3	14·25 in.	·09 in.	1·15 in.	·008 in.	87	13

30th January, 1883.

The Rev. CANON GRAINGER in the Chair

A Paper was read by Mr. WILLIAM GRAY, M.R.I.A., entitled

NOTES ON HOUSE DRAINAGE.

THE object of Mr. Gray's communication was to show that all house drains should be simple in construction, effective in operation, and, above all, arranged so that the house should be completely cut off or disconnected from the town sewers. Having referred to the medical testimony as to the many evil consequences resulting from defective house drains, Mr. Gray described a number of cases within his own knowledge in Belfast, where, in otherwise well ordered houses, the drains were in a stinking condition of filth and neglect, and calculated to promote disease and death ; Mr. Gray strongly recommended every householder to examine his drains, and if this was done it would be found that grossly defective drains were the rule, and not the exception. When drains are entirely covered up, as they commonly are, the householder cannot examine them as frequently as he should do ; indeed, he is thereby often prevented from looking after them at all. No system of drainage therefore can be complete that is not *open for examination*, and it cannot be too generally known that it is possible to have a most effective and simple plan of drainage, *quite open* for thorough examination. Any drain will occasionally go wrong ; if hidden, that wrong or defect will increase, and if the arrangements are complicated,

the defect cannot readily be discovered; but if simple in construction, and open for inspection, the defect can be seen at once and removed.

All house refuse should be discharged into *the open air* as quickly and completely as possible. It is confined refuse, allowed to ferment, that generates injurious gas and poisonous air. All liquid refuse, or what is carried off by water drainage, should first be received into a trapped receptacle, like a water closet or jaw-box, (scullery slop tank). Such receptacles should be as near the external wall of the house as possible, and through this wall the refuse should be discharged into an *open pipe*, such as a soil pipe, for example. This pipe should be open at *top* and at *bottom*. The upper portion of the pipe, to ventilate the top, should be sufficiently large, and carried above the eave of the house, and so long as the external soil pipe is thus *open* and therefore *ventilated* it cannot contain injurious gas; but if it is closed at top or bottom, or at both ends, it must generate foul air. The more common practice is to have the soil pipe closed at top, carefully closed by an expensive lead bend, and at the bottom, discharging directly into the main sewer; thereby conducting all the abomination of sewer gas as effectively into the dwelling as the town water is laid on. This arrangement cannot be too strongly comdemned. Sometimes the soil pipe is trapped at the bottom, yet directly connected with the sewer. This arrangement is also defective, because, first, the soil pipe is not properly ventilated, as there is no circulation of air throughout it, and secondly, the trap at foot is not sufficient to prevent the return of sewer gas from the main drain. Mr. Gray very strongly recommended the adoption of an *open soil pipe*—that is, open at top and bottom. This soil pipe should be discharged directly into an *open gully* trapped at the town side. The *open gully* is simply an *open* chamber forming a quick connexion between the foot of the soil pipe and the mouth of the syphon trap, and for this purpose the bottom of the gully has a rapid fall, so that nothing could rest upon it. The syphon trap should be as near the gully as possible, so as to be reached from the gully for cleansing, and by this very simple arrangement all local

pollution will be prevented, and the dwelling cut off from the main sewer. The local pollution that collects about ordinary bell traps and catch-pits, is as offensive and injurious to health as the direct flow of sewer gas. Mr. Gray advocated that the open gully just described, should, if possible, be the receptacle for all the drainage of the house, from closet, bath, and scullery, and that, by this means, the seat of the one trap cutting off the town sewer would be always charged, and thereby prevent the return or absorption of sewer gas. The gully should be covered by a moveable open grate which will admit of removal for examination, and will also allow the syphon trap to be cleared in case of obstruction. With this arrangement it would simply impossible for any injurious sewer gas to return into or about the dwelling, and the open character of the system admits of complete supervision and therefore the immediate detection of any local pollution that may collect from carelessness.

Mr. Gray described the several patented and other devices for accomplishing the same end, but all were more or less defective, or too complicated for practical application, and therefore he strongly advocated the adoption of his system, which was simple in construction and thoroughly effective in its operation.

6th February, 1883.

The President, R. L. Patterson, Esq., in the Chair.

A Paper was read by Mr. S. A. Stewart, F.B.S.E., on

RATHLIN ISLAND, WITH NOTES ON ITS NATURAL HISTORY AND ANTIQUITIES.

Some attention has been paid, of late, to the botanical characteristics of the islands lying off the Irish coasts, and investigations, set on foot by the Royal Irish Academy, have been carried on by Mr. A. G. More, in Inisbofin and Inishark ; by Mr. R. M. Barrington, in the Blasquets and Skellog ; and by Mr. Hart, in Tory Island. The lists already published have proved interesting, and have thrown much light on the distribution of plants in this country, and it was considered desirable to have a botanical survey of the Island of Rathlin. This work occupied three weeks : one week in April, another at the end of June, and again at the commencement of August. In this way it was possible to note the various plants of Spring, Summer, and Autumn, as well as to note many points of interest in other departments of natural science.

Rathlin lies off the Antrim Coast in 55° 15′ N. latitude, 6° 10′ W. longitude. The most southerly point of the island approaches to less than four miles from Fairhead, on the mainland ; but the distance from the quay at Ballycastle to the usual landing place in Church Bay, is about seven-and-a-half

miles. The western extremity of Rathlin, called Bull Point, looks away to the Atlantic Ocean, while the eastern side faces Cantyre in Scotland, distant about fourteen miles. The island presents steep escarpments to the sea throughout nearly the entire extent of its coast line, Church Bay, opposite to Ballycastle, being the only exception of any consequence. At the south or Ushet end the cliffs are comparatively low, but they rise steadily to the north and west until they attain an altitude of 300 to 400 feet. The geological structure of the country is simple, but nevertheless possesses many points of interest; and the cliffs afford the very best sections for this study. Two classes of rocks are developed—the igneous and the sedimentary. The stratified rocks consist of the white limestone of the cretaceous series, and differ in no way from the white rocks so conspicuous on the Antrim coast. The igneous rocks consist of several varieties of trap, in some cases hard and compact, in others amygdaloidal. Ash beds of considerable thickness are to be seen at the north-east. Iron is an important constituent of these rocks, some of the sections being coloured by the red oxide. In several places at the south-east a columnar structure is developed like that at the Giant's Causeway. Though the pillars are often quite regular, yet the peculiar horizontal jointing so beautifully displayed at the Causeway is here only a subordidate feature, or exists in an imperfect form. Dr. Hamilton stated that the Ballycastle coalfield extends to Rathlin, but I could not discover the coal-measure rocks anywhere.

By reason of the isolation of Rathlin, its natural history possesses more interest than that of a similar area on the mainland. In such a place we expect to find only the really native animals and plants: the indigenous fauna and flora of the country, venerable by reason of antiquity, and cut off to a great extent from the immigration of strangers. This is well seen in Rathlin. Thus the common frog, an importation to Ireland of recent time, has not yet made its way into the island, though so abundant on the mainland a few miles off. And the same is true of the water thyme (*Anacharis*), which is not to be

found in the Rathlin waters. The brown rat, however, whose power to spread and increase seems unlimited, is common on the island, and a decided pest there as elsewhere. Dr. Hamilton, in his account, says there are no mice in Rathlin;—if that were so in 1784 it is not the case now, as at present they are only too plentiful.

As may be expected where the limits are so narrow, there are few really native quadrupeds. There are indeed wild goats, but they are domesticated animals, turned out by Mr. Gage, to live in a state of nature. The place occupied by the goats is naturally inaccessible on the land side, but a wire rope hung over the cliff by the proprietor, enables the firm of nerve and sure of foot to descend. In this secluded spot grows the grass of Parnassus (*Parnassia palustris*), almost the only place on the island where this beautiful flower can be found. Owing to their atrocious slaughter by a person who would like to be considered a sportsman, the "wild goats" have been reduced to two animals only. The hare has also been introduced, and is not uncommon on the heaths. But it is the sea-birds which may be regarded as the glory of Rathlin Island. The west and northwest, where the cliffs are highest, is their favourite locality. Here they congregate in thousands, and he must be hard to please, indeed, who would not be delighted with the scene on a midsummer day. Dunmore, on the west, is a sight to see in June. This a great stack or pillar detached from the cliffs, and rising to somewhere about 100 feet high. It is so close to the shore that its base can be reached at low water, but its perpendicular sides forbid any attempt at climbing beyond a few feet. This rock is the headquarters of the puffins and guillemots, and at the end of June was so closely packed on the top and on the numerous ledges down the sides, that it seemed as if there was not room for another bird. Storms and high winds are continually sweeping over this bare exposed crag, and it is a marvel that the birds are able, notwithstanding, to keep their places, and bring out their young. At the end of July, not more than the tenth of the birds remained, and the base of the rock was strewn with empty egg shells. The Cornish Chough is a con-

spicuous feature in the ornithology of Rathlin. It is called, by the natives, the Jackdaw, and is plentiful over the island. Eagles are said to frequent Rathlin, but they may be deemed rare visitors now.

The plants collected, or noted, during my three visits, number 320 species, being about one third of the members of the Irish flora. The list may be taken as representing nearly everything that grows spontaneously on the island : and includes a good number of plants which are not commonly met with. Two of these, viz. : *Potamageton pseudaniteus*, and *Stachys ambigua*, though not raised by British botanists to the dignity of species, are yet well marked and interesting varieties which had not been recognized in Ireland. Miss Gage, an accomplished lady, who resides in Rathlin, has an album filled with sketches, executed by herself. These sketches, which are accurately drawn and beantifully coloured, represent the greater part of the Rathlin plants. Miss Gage has also figured, in a similar manner, the birds and the butterflies found there, and to one interested in such subjects it is really a treat to be permitted to look over these albums.

Rathlin, like every other place, has been credited with plants that do not really grow there, and from the previously published list a good many species must be deleted, the most important of these being the pipewort (*Eriscaulon septangulare*). The flora of Rathlin is, on the whole very good, considering that owing to the want of woodlands, or even thickets, there is necessarily a nearly total absence of sylvan species. A few plants that love the shade manage to exist in the shelter of the rocks, but they are only a small number. Cold and boisterous weather also excludes such as require warm sunny conditions. Owing to the rocky surface, and uneven form of the country, small lakes and ponds abound, and in consequence, we get in Rathlin, a lacustrine flora of more than average extent and interest. The Hornwort (*Ceratophyllum demersum*), occurred in the large lake at Ushet, and pondweeds are abundant and varied. The limited time available for the investigation, did not allow of full justice being done to cryptogamic plants, and

nothing was attempted except the moss-flora. The collection amounts to about 70 species, and though by no means exhaustive, it contains some of the rarer and more interesting of our mosses, and indicated that the bryology of Rathlin would repay a more systematic search.

6th February, 1883.

The President, R. L. Patterson, Esq., in the Chair.

A Paper was read by Mr. Wm. H. Patterson, M.R.I.A., on

ETCHING ON COPPER.

Having enumerated the various ways of engraving on metal plates for the purpose of producing printed impressions, Mr. Patterson described more particularly the process of etching on copper. Ordinary etching, in the different positive and negative manners, was described, as well as soft ground etching, aquatint, &c. Copper plates were exhibited in various states, with prints from the same ; and some of the needful utensils of the art were shown. Mr. Patterson showed a series of printed etchings, from plates which he had completed, printed in different coloured ink, &c.

27th February and 6th March.

The President, R. L. Patterson, Esq., in the Chair.

Two Lectures were delivered by Professor E. A. Letts, on the

SPECTROSCOPE AND ITS USES.

10th April, 1883.

The President, R. L. Patterson, Esq., in the Chair.

A Paper was read by Rev. R. Workman, Newtownbreda, on

THE WARFARE OF ANCIENT IRELAND.

This paper was the result of an inquiry into the facts and practices of Irish warfare, from the English invasion till the settlement of Ulster, with a view to throw light on the social condition of Ireland during this period.

Three races made this country their battle ground ;—the English, the native Irish, and the Scots from the Western Isles. Besides this, the native Irish, divided into hostile clans, made constant war upon one another, to such an extent as reduced the country to desolation, and made improvement impossible.

The native Irish soldiery were hardy and irrepressible, able to dispense with shelter, and to bear hardships to an extraordinary degree. They had neither castles nor forts to stand a siege, their plan was to make sudden raids on the English, and carry off the cattle into woods and bogs that were inaccessible.

The dress and accoutrements of the Irish and Scots were very primitive, and they had little mercy for the vanquished.

The reader showed that the English also treated their Irish foes with great cruelty, which he attributed to their regarding them as barbarous beyond possibility of civilization.

Under such circumstances, very little tillage was practised ;—the population was too moveable, and the chance of being

allowed to reap what was sown was too small, to encourage men to labour. The natives depended on their cattle, which they drove about with them ; hastily built huts sheltered them, and indoor life was practically unknown during the day time.

Under such circumstances, man must sink into the lowest state of civilization ; industries and arts of all sorts were impossible ; accordingly this period of Irish history has left no memorial ; population decreased, and wild beasts multiplied so that the skins of foxes were sent over from our island to the Low Countries. Even religion itself seemed to have lost all power to influence the community, as might be expected when the sole occupation of the people was war.

Report and Proceedings

OF THE

BELFAST

Natural History and Philosophical Society,

FOR THE

SESSION 1883-84.

BELFAST:
PRINTED BY ALEXANDER MAYNE, CORPORATION STREET.
(PRINTER TO THE QUEEN'S COLLEGE.)

1884.

Report and Proceedings

OF THE

BELFAST

Natural History and Philosophical Society,

FOR THE

SESSION 1883-84.

BELFAST:
PRINTED BY ALEXANDER MAYNE, CORPORATION STREET.
(PRINTER TO THE QUEEN'S COLLEGE.)

1884.

CONTENTS.

Belfast Natural History and Philosophical Society.

ESTABLISHED 1821.

SHAREHOLDERS.

1 Share in the Society costs £7.			
2 Shares	,,	,,	cost £13.
3 Shares	,,	,,	cost £21.

The proprietor of 1 Share pays 10s. per annum ; the proprietor of 2 Shares pays 5s. per annum ; the proprietor of three or more shares stands exempt from further payment.

Shareholders only are eligible for election on the Council of Management.

MEMBERS.

There are two classes, Ordinary Members, who are expected to read Papers, and Visiting Members, who, by joining under the latter title, are understood to intimate that they do not wish to read Papers. The Session for Lectures extends from November in one year till May in the succeeding one. Members, Ordinary or Visiting, pay £1 1s. per annum, due first November in each year.

PRIVILEGES.

Each Shareholder and Member has the right of personal attendance at all meetings of the Society, and of admitting a friend thereto ; also of access to the Museum for himself and family, with the privilege of granting admission orders for inspecting the collections to any friend not residing in Belfast.

Any further information can be obtained by application to the Secretary. It is requested that all accounts due by the Society be sent to the Treasurer.

The Museum, College Square North, is open daily from 12 till 4 o'clock. Admission for Strangers, 6d. each. The Curator is in constant attendance, and will take charge of any Donation kindly left for the Museum or Library.

BELFAST

Natural History and Philosophical Society.

ANNUAL REPORT 1884.

THE Council for the year 1883-4, appointed by the Shareholders at their annual Meeting, on the 19th June, 1883, desire to present to their meeting the Report of the working of the Society during the past year.

The Winter Session was opened on November 6th by an address by the President, Professor Cunningham, the subject selected being "The Extinct Floras of the British Islands." The second paper was read on December 4th, by Mr. Joseph John Murphy, and was a communication from Professor Heddle, of St. Andrew's, on "Agates." Mr. William Gray followed with a notice of "The Sand Hills of Ballintoy." On January 8th, 1884, there were two papers, one by Mr. Joseph Wright—"Remarks on the Tendency to Variation in Foraminifera, as illustrated in the Genus Lagena"; the other by the Rev. George Robinson, on "The Occurrence of some Rare Birds at Lough Neagh since 1876." On February 5th, a paper was read by Professor Meissner, Ph.D., Queen's College; subject: "Heathen Antiquities in Christian Churches." On February 12th, Mr. William Hancock, F.R.G.S., of the Chinese Imperial Customs Service, read a paper on "North Formosa; its Physical Geography, Flora, Fauna, and Aborigines." On March 4th there were two papers; the readers were Mr. F. W. Lockwood, on "Sanitary Protection Associations; their Success and Mode of Operations," and Mr. Robert Young, who gave "A Notice of some North American Stone Implements." The concluding

paper of the Session was by Mr. Robert Lloyd Patterson ; subject : "Migratory Birds." On each of these evenings, except the last, the chair was occupied by the President, Professor Cunningham ; on the last evening, Professor Everett presided, in consequence of the President's absence from Belfast. The attendance of members and visitors at the evening meetings was fairly maintained.

The Secretary, Dr. Workman, having resigned his office, in consequence of leaving Belfast, Mr. W. H. Patterson was appointed to the vacant post.

A list of Donations to the Museum, and of Reports and other Publications for the Society's library, is to be printed with the present Report. The Council would thank the various donors for their valuable gifts.

The Museum was opened on Easter Monday to the public, at a charge of two pence for adults, and one penny for children, and the attendance was, as usual, very large.

The storms of last Winter occasioned some damage to the roof and walls, but these, along with some defects that came to light in the curator's house, have been made good. The Council reports that the buildings are in good order, and that the collections are also in good order, and in several respects in an improved condition.

The re-arrangement of the Foreign Shells in the Museum has, with a small exception, been completed. This large collection has been removed to the gallery, and now occupies the wall cases on the south side. The series includes representatives of all the great families of testaceous Mollusca. The total number of specimens mounted at present is very nearly 7000, made up as follows :—Gastropods, genera 131, species 1320, specimens 5467. Bivalves, genera 75, species 584, specimens 1362. These have been completely classified, mounted in their proper order, and, with the assistance of Messrs. Workman and Swanston, labelled with dates and localities, as far as could be ascertained. The fine set of American fresh-water shells is displayed in the gallery flat cases. The cases which contained the general collection of minerals have been re-painted, and the

specimens are being arranged according to the sequence of Dana's manual. The labels, which were becoming illegible through age, are being renewed, and the specimens displayed to the best advantage. It would seem that the four cases which this collection of minerals has hitherto occupied, will not now suffice to hold all the specimens, unless they be very much crowded. It, therefore, becomes a question whether some of them shall be left out, or whether it may not be advisable to make use of one or two of the flat cases at present in the lecture hall, filled with miscellaneous matter.

The Treasurer's Account is submitted herewith.

Your Council now retire from office, and this meeting will be asked to select fifteen members to form a new Council.

The Belfast Natural History and Philosophical Society, in account with Treasurer. For Year ending 1st May, 1884.

Dr. **Cr.**

EXPENDITURE.

	£	s.	d.
To Balance	£15	7	6
,, Cash paid Insurance Premiums	8	15	4
,, ,, ,, Printing Report	6	0	6
,, ,, ,, Advertising	1	16	10
,, ,, ,, Printing and Stationery,	8	13	8
,, ,, ,, Outfit for Tea Meetings	4	1	0
,, ,, ,, Repairs to Roof, &c.	5	6	10
,, ,, ,, Rent till 1st May	25	0	0
,, ,, ,, Collecting Subscriptions	6	14	6
,, ,, ,, William Darragh, Salary till 1st May	48	0	0
,, ,, ,, S. A. Stewart, Salary till 1st May, less four months' leave	33	6	8
,, ,, ,, Expenses on Easter Monday	7	7	0
,, ,, ,, Coal, Coke, and Gas	12	17	9
,, ,, ,, Small Accounts	7	0	10
,, ,, ,, Balance in hand	0	17	3
	£191	5	8

RECEIPTS.

	£	s.	d.
By Interest on York Street Loan	£19	11	9
,, Contribution from Naturalists' Field Club	5	5	0
,, ,, from Engineers' Association, 1882-3, 1883-4	8	6	0
,, Contributions from Philo-celtic Society, (on Account)	1	0	0
,, Transfer Fees	0	7	6
,, Donations	2	18	6
,, One Share sold	7	0	0
,, Subscriptions and Arrears for year ending November, 1882	98	3	0
,, Entrance Fees at door, till 1st May	16	2	6
,, ,, Easter Monday	32	11	5
	£191	5	8
By Balance	£0	17	3

Examined and found correct,

Wm. H. Patterson,
Samuel Andrews, } *Auditors.*

J. BROWN, *Hon. Treasurer.*

DONATIONS TO THE MUSEUM, 1883-84

From Mr. John Browne, M.R.I.A., Cookstown.

Antique steel sword, dug up in the City of Londonderry, in October, 1836.

From Captain Robert Campbell, of the Ship Slieve Donard.

Twenty-five figures of Natives of India, in their usual costumes; two necklaces, two pair of bracelets, and one string of beads, made of Delhi grass; One Indian hookah, one Indian mat, and one Indian weapon; specimen of pumice, from the recent eruption at Karakatoa, found floating at sea, 1200 miles from Java.

From Major Crawford, J.P., D.L.

A curiously twisted branch, found at Rademon, County Down.

From Mr. Daniel Devlin, Coalisland.

A nodule of decomposing coral (Lithostrotian).

From Mr. William Gray, M.R.I.A.

A stone muller from North America; five specimens of reversed helices.

From Rev. H. W. Lett, Ardmore.

Specimens of mosses for the herbarium.

From Dr. James Moore, M.R.I.A.

Fragments of ancient sepulchral urns; locks and fetters used in the old County Gaol at Carrickfergus; some ancient military accoutrements.

From Mr. R. Lloyd Patterson, J.P., F.L.S.

Male and female specimens of the upland goose.

From Mr. Alexander Richardson, Lambeg.

A lizard's skin, and two snakes' skins.

From Mr. Robert Young, C.E.

Specimens of flint instruments, and of ancient pottery, from North America.

From Mr. R. M. Young.

A collection of cryptogamic plants, made by the late Mr. John Templeton, mostly during the years from 1804 to 1809.

LIST OF BOOKS RECEIVED, 1883-84.

ADELAIDE. — Transactions of the Royal Society of South Australia. Vol. 5, 1882 ; vol. 6, 1883. *The Society.*

Description of new species of Squilla, by Professor Ralph Tate, F.G.S., F.L.S. *The Author.*

BELFAST.—Proceedings of the Belfast Naturalists' Field Club, 1882-3. *The Club.*

BERLIN—Verhandlungen der Gesellschaft fur Erdkunde. Nos. 5, 6, 7, 8, 9, 10 of vol. 10, 1883, and number 1, vol. 11, 1884. *The Society.*

BOLOGNA.—Accademia delle Scienze, Rendiconto delle sessione, 1882-3. *The Society.*

BOSTON.—Proceedings of the Natural History Society of Boston. Part 4, vol. 21 ; and part 1, vol. 22, 1883. *The Society.*

BRIGHTON.—Annual Report of the Brighton and Sussex Natural History Society, 1883. *The Society.*

BRUSSELS.—Bulletin de la Societe Royale de Botanique de Belgique. Vol. 22, 1883. *The Society.*

Bulletin de la Societe Entomologique de Belgique. Series 3, nos. 41, 42, 43, 1884. *The Society.*

Societe Royale Malacolgique de Belgique, proces-verbal. August, 1882 till July, 1883. *The Society.*

CALCUTTA.—Memoirs of the Geological Survey of India. Parts 2, 3, 4 of vol. 19 ; and parts 1 and 2 of vol. 20.

Palæontologia Indica, series 10 ; vol 2, parts 4, 5, 6 ; vol. 3, part 1 ; series 12, vol. 4, part 1 ; series 13, vol. 1, part 4, fasc. 1 and 2 ; series 14, vol. 1, parts 3 and 4.

Records, vol. 15, part 4 ; vol. 16, parts 1, 2, 3, 4 ; vol. 17, part 1. *The Superintendent of the Survey.*

CHRISTIANIA.—Jahrbuch des Norwegischen Meteorologischen Instituts for 1877-78-79-80-81.

Etudes sur les Mouvements de Atmosphere, deuxieme part, 1880.

Fortegnelse over den Tilvæst som det Konelige Frederiks Universitets Bibliothek har erholdt, 1879.

Det Kongelige Norske Frederiks Universitets Aarsberetning, 1878-79-80-81-82.

Enumeratio Insectorum Norvegicorum, fasc. 5, pars. 1, 1880

Forhandlinger Videnskabs Selskabet, I., Christiania, 1878-79-80-81-82. *The University.*

DUBLIN.—Transactions of the Royal Dublin Society. Series 2, vol. 1, part 19. *The Society.*

EDINBURGH.—Transactions and Proceedings of the Royal Society of Edinburgh. Part 3, vol. 14, 1883. *The Society.*

List of Council and Members of the Royal Society of Edinburgh, 1883.

Transactions and Proceedings of the Botanical Society. Vol. 15, part 1. *The Society.*

EMDEN.—Siebenundsechszigster Jahrebericht der Naturforschenden Gesellschaft, 1881-2. *The Society.*

GENOA. — Giornale della Societa di Letture Conversazione Scientifiche. Vol. 7, parts 8, 9, 10, 11, 12; vol. 8, fasc. 3, 4, 5, 6, 7. *The Society.*

GIESSEN.—Oberhessischen Gesellschaft fur Natur und Heilkunde, 22nd Report, 1883. *The Society.*

GLASGOW.—Proceedings of the Natural History Society of Glasgow. Vol. 5, part 2, 1883. *The Society.*

Proceedings of the Philosophical Society of Glasgow. Vol. 14, 1883. *The Society.*

HARVARD, U.S.A.—Bulletin of the Museum of Comparative Zoology. Vol. 10, nos. 5 and 6; vol. 11, nos. 1, 2, 3, 4, 5, 6, 7, 8, 9. *The Museum.*

LAUSANNE. — Bulletin de la Societe Vaudoise des Sciences Naturelles. No, 89, December, 1883. *The Society.*

LIVERPOOL.— Proceedings of the Literary and Philosophical Society. Vols. 35, 36, 37, 1881-83. *The Society.*

LONDON—Journal of the Royal Microscopical Society. Series 2, vol. 3, parts 3, 4, 5, 6, 1883 ; vol. 4, parts 1 and 2, 1884.

List of Fellows, 1884. *The Society.*

Memoirs of the Royal Astronomical Society. Vol. 47, 1882-3. *The Society.*

Proceedings of the Zoological Society. Part 4, 1882 ; parts 1, 2, 3, 4, 1883.

List of Fellows, 1883.

List of Animals, 1883.

Catalogue of Library—Supplement, 1883. *The Society.*

Proceedings of the Society for Psychical Research. Vol. 1, parts 2 and 3. *The Society.*

Scientific Roll (Climate). Vol. 1, part 2, no. 10, February, 1883. *The Editor.*

MADISON.—Geological Survey of Wisconsin. Vols. 1 and 4, with Atlas of Maps, 1882-3. *The Survey.*

MANCHESTER.—Transactions of the Geological Society of Manchester. Vol. 17, parts 8—15, 1883-4. *The Society.*

NEW YORK.—Bulletin of the American Geographical Society. Nos. 2, 3, 4, 1883. *The Society.*

PHILADELPHIA.—Proceedings of the Philadelphia Academy of Natural Sciences. *The Academy.*

PISA.—Atti della Societa Toscani di Scienze Naturali, several parts. Processi Verbali Adunanza del di, 13th January, 1884 and 2nd March, 1884.

ROME.—Atti della Accademia dei Lincei. Vol. 7, fasc. 9—16 ; vol. 8, fasc. 1, 2, 3, 4, 5, 6, 9, 1883-4. *The Academy.*

Atti Parlimentari, ccxliii, 15 Marzo, 1884.

SACRAMENTO.—Third Annual Report of the State Mineralogist, 1883. *H. G. Hanks, State Mineralogist.*

SCARBOROUGH.—Report on the Sanitary Condition of Scarborough during the Year 1883.

Scarborough as a Health Resort.

Dr. J. W. Taylor, D.Sc., Medical Officer of Health, Scarborough.

SONDERHAUSEN.—Irmischia. Nos. 1 to 12, 1883 ; nos. 1 and 2, 1884.

Die Torfmoose der Thuringischen Flora.

VIENNA.—Verhandlungen der Kaiserlich Koniglichen Geologischen Reichsanstalt. Parts 17 and 18, 1882 ; and parts 1 to 18, 1883. *The Society.*

Verhandlungen der Kaiserlich Koniglichen Zoologisch-botanischen Gesellschaft. Vol. 32, 1882. *The Society.*

Mittheilungen des Ornithologischen Vereins, Nos. 1 to 12, 1883 ; nos. 1, 3, 4, 5, 1884. *The Society.*

Maygar Novenytani Lapok. Vol. 7, 1883. *The Society.*

WARWICK.—Proceedings of the Warwickshire Field Club, 1882. *The Society.*

WASHINGTON.—Report of the Smithsonian Institution, 1881. *The Institution.*

YOKOHAMA.—Mittheilungen der Deutschen Gesellschaft fur Natur and Volkerunde Ostasiens, Band 3, 1882. *The Society.*

PRESIDENTIAL ADDRESS:

THE EXTINCT FLORAS OF THE BRITISH ISLANDS,

DELIVERED BY

ROBERT CUNNINGHAM, Esq., M.D., F.R.U.I.,
Professor of Natural History and Geology, in Queen's College, Belfast,

On Tuesday Evening, 6th November, 1883.

The President commenced his address by making a complimentary reference to the interesting historical sketch of the rise and progress of the Society with which his respected predecessor, Mr. R. L. Patterson, inaugurated his presidency. He (the President) thought nothing could be more appropriate, coming as it did from a gentleman the memory of whose father they all honoured, he having been one of the original founders and also one of the most vigorous supporters of the Association. He (Dr. Cunningham) had chosen as his theme the "Extinct Floras of the British Islands." In order clearly to understand the relationship existing between the different extinct floras, it was necessary to place before them the great sections into which the rocks have been divided—Palæozoic (primary), Mesozoic (secondary), Kainozoic (tertiary), with their different divisions into strata, beginning with the oldest, the Laurentian, and ending with the Quaternary. The President pointed out that the Laurentian are so called from extensive beds which had been discovered near the St. Lawrence River, and that little of this formation has been discovered in the British Islands. He also

referred to the various extinct floras found in the Cambrian and Silurian formations, and dwelt at length on the flora of the Devonian and Old Red Sandstone, in describing which he paid a passing tribute to the memory of the late Hugh Miller, with whose name this stratum is intimately connected. As might be expected, the coal-producing strata in the lower part of the carboniferous formation is very rich in fossil plants. The lecturer entered into a lengthened description of these fossils, pointing out many of their distinguishing and more interesting characteristics, including their agreement with certain species at present existing in the southern hemisphere, a circumstance which proves that our country at that time possessed a much warmer climate. The Permian, of which very little is found in these islands, is very deficient in extinct floras. The second and third great section of rocks have fossil plants more nearly approaching those still growing in our islands. As a general rule, while the plants that were in existence during the formation of rocks in the Primary section were Monocotyledonous, those in the Secondary and Tertiary were principally Dicotyledonous. The lecturer concluded by a graphic description of the leaf beds of Bovey Tracey, Island of Mull, and the northern part of County Antrim.

6th November, 1883.

The President, Dr. Cunningham, in the Chair.

AN ANCIENT ALTAR STONE.

The Hon. Secretary directed the attention of the meeting to a very curious object of Irish antiquarian interest, an ancient altar stone, the property of Mr. Robert Brown, Kildrum, Kells, near Ballymena, which Mr. Brown had very kindly deposited in the Museum for exhibition.

4th December, 1883.

The President, Dr. Cunningham, in the Chair.

Mr. Joseph J. Murphy read a letter from M. Foster Heddle, on

AGATES.

The following letter was addressed by the writer in 1871 to Mr. Joseph John Murphy, and though not originally intended for publication, is now submitted to this Society with the writer's consent:—

St. Andrew's, *November* 4, 1871.

Dear Sir,—I have on my return found your note as to Agates. Though I have been at work on the subject in different ways for many years, I have not found myself in a position yet to publish. In fact I cannot yet say that I *know* much as to how they have been formed, though I do know, or rather am able to show, that they have not been made in the manner usually supposed.

The late Principal Forbes conceived that they had been formed by concentric deposition round a central nucleus:—this I showed him to be untenable. Others conceive that siliceous matter in a state of fusion has been poured into cavities through an opening, such opening being called the "point of infiltration." I am able to show that this so-called point of infiltration is an orifice of escape or exit of something.

Fully to state how (from examination of their mode of occurrence, experiments upon the decomposibility of trap rocks under the action of carbonated water, section of agates in every conceivable direction, experiments upon their powers of absorbing liquids, and from microscopic examination) I conceive agates to be formed, would call for indeed a long statement.

I will attempt briefly to put it thus:—

Igneous rocks are being poured forth from a volcanic vent, in perfectly fluid or at least plastic flow; some are dense, some scoriaceous, some frothing, and so when solidified are vesicular, or perchance even hold in suspension bubbles of included water, this latter holding in solution (red-hot solution) solids afterwards to separate as rheolites. Should the air-bubbles of the vesicular rocks arise through the plastic mass while it is motionless, these bubbles will be more or less rounded or pear-shaped. Should the solidifying rock, however, become crystalline or porphyritic, as generally is the case with amygdaloids, the separating crystals of labradorite, &c., will more or less roughen the sides, and so destroy the smooth and rounded figure of the cavity; while, if the lava-flow continues its motion while the bubbles are still rising, their shape will be more or less flattened or altered:—try bubbles in flowing treacle.

Stage the first.—An empty cavity of any shape.

Stage the second.—The rock, while solidifying, may contain an excess of a magnesian mineral, which is exuded into the cavity; or this excess of magnesian compound (magnesia not being, to any large extent, a *natural* constituent of the mass of a trap) may be held as vapour in the cavity, to be, on cooling, deposited on its sides. This forms in Scotland, Faroe, Iceland, &c., the layer of celadonite or delessite; at Giants' Causeway, of chlorophœite, which, on the extraction of the afterwards filled-up cavity, forms the "skin of the pebble."

Stage the third.—One of two processes, the first very doubtful. The cooling and shrinking rock holds in a state of *liquidity, from heat,* an excess of colloidal silica, which is exuded into the cavity, forming a chalcedonic druse. But, admitting the process, it must here stop, and a *solid* agate could not thus be formed. This seems to have been the view of Sir George Mackenzie.

The other process I pin my faith to. The thoroughly solidified—indeed the now *old*—rock is having its felspar (labradorite or other) decomposed by water holding carbonic acid in solution. I have proved that this process is rapid and continuous, and

agate-holding traps are all rotten; the colloidal silica, with a certain quantity of *tridamyte*, is taken up by this water, and transfuses into the cavity; the silica is there solidified—probably the layer of delessite is the coagulation. We have now a cavity slightly lined with chalcedonic matter, containing, within, water more or less pure, while without (that is outside of the now double skin, delessite and first layer) we have a strong solution of colloidal silica constantly supplied. Endosmose and exosmose are set up with all their resistless force. The *strong* solution finds its way through the two or any number of increasing skins: the *weak* water is forced out through the "point of infiltration," and so in its passage out thins all the successively deposited layers *at that place*. By this continuous flow of colloidal silica (held in solution by liquid) through the already coagulated or deposited layers, continuous coagulation of the silica in the yet hollow agate, and continuous extrusion of the residual water, we have the ultimate filling up of the cavity, and a solid agate formed.

The adhesion of agates to the containing rock is slight in most cases, from the so-called "skin" being magnesian and soapy.

The "point of infiltration," instead of being at once filled up, as would result from the inflow of coagulable silica, is in reality the last point filled up, being truly the point of escape: indeed it frequently is not altogether filled up, *remaining an open tube*.

The microscope shows on a cross section the concentric layers of coagulated silica, soluble in alkalies; the crystals or fibres of *tridamyte* cross these layers at right angles, radiating like a rheolite from the skin, and it is always along the sides of these crystals that intruding and staining liquids find a way; probably, therefore, along their sides also did the ingress of chalcedonic fluid find entrance.

I remain very truly yours,

M. Forster Heddle.

4th December, 1883.

The President, Dr. Cunningham, in the Chair.

Mr. William Gray read a Notice of

THE SANDHILLS OF BALLINTOY.

Mr. Gray exhibited a curious urn of rough earthenware, from the north of the County Antrim. Mr. Gray was not quite certain that the urn was genuine, but he explained that a large number of objects of antiquity are found at Whitepark Bay, Ballintoy, including a number of urns, some quite perfect, and containing burnt bones. They are generally found along the slopes of the undercliff, or talus between the sand dunes and the cliff face. The sand dunes are extremely rich in flint and stone implements, and the number of cores, hammers, flint chips, and fragments of food vessels that are collected here from time to time, indicate that the bay was the site of ancient settlements which were occupied for a very long time. There are many remains of antiquity in the neighbourhood. In the bay there are the remains of an ancient burial place, within a rude stone circle, and above the bay there are no less than three fair cromlechs ; one of them is a little above the rectory, and this too is enclosed by a rough stone circle.

8th January, 1884.

The President, Dr. Cunningham, in the Chair.

Mr. Joseph Wright, F.G.S., made a statement concerning

FORAMINIFERA.

Mr. Wright referred to his investigations on Foraminifera, especially in connexion with the genus Lagena. He mentioned interesting results of dredgings made by himself and Mr. Balkwill, off the coast of Dublin, when, amongst other species, was found the Lagena Castrensis, known previously only as a recent species from off the Australian coast.

8th January, 1884.

The President, Dr. Cunningham, in the Chair.

Rev. George Robinson, Armagh, read a Paper on the

OCCURRENCE OF RARE BIRDS AT LOUGH NEAGH SINCE 1876.

The reader mentioned, with special reference, seven rare birds which had occurred at Lough Neagh since 1876. These were —the Canada goose, the black tern, the pigmy curlew, the long-tailed duck, the ruff, the eider duck, and the scoter duck. It was at first supposed the Canada goose, which was observed on the southern shore of the Lough in 1877, was an escape, but that idea has since then been abandoned, and it is now established that the Canada goose which occurred at Lough Neagh was a truly wild bird. But a somewhat strange circumstance is that a wild goose has never been procured in that district, and although wild geese have been often observed flying over the Lough, they are never seen to alight, and he never knew of one being shot on the southern shore. The black tern is a very rare bird. It does not breed in Ireland, but it occasionally occurs on our coast about the autumnal migration. He had only seen one of them before, and that was a bird shot at Plymouth. The pigmy curlew was observed in 1878. It usually occurred on the seashore of Ireland and also in England. The long-tailed duck was shot in a locality between Portadown and the Lough, alongside the River Bann, where, no doubt, it had been driven by stress of weather. The eider duck was purchased by a gentleman in Armagh, who takes a great interest in ornithology, (Mr. Templar,) from a woman

who was selling ducks. He had seen in the *Field* that an eider duck was recently found near Norwich, twenty miles from the sea coast. The next of the rare birds to which he would call attention was the scoter duck, which is also a true sea bird. The seventh of the rare birds is the ruff. It is a very strange-looking bird in its summer plumage, a curious frill appearing along its neck, which it can puff out to a surprising extent. It, too, is confined to the autumnal migration. The only specimen he ever saw was one in a market in Dublin. Two of these birds were shot near Lough Neagh. The ruff belongs to the eastern districts of England, but the species is rapidly disappearing there, owing to the reclamation of the marshes which it frequents. He regarded it as an interesting addition to the birds of the County Armagh. Having gone over the list of rare birds which had occurred at Lough Neagh within a very recent period, covering about seven years, at the rate of one each year, he would now refer to some birds that are disappearing from the Lough and the district about it. Among these are the grey-crested grebe, a most beautiful water fowl ; the yellow wagtail, a bird peculiar to Lough Neagh ; and the quail, formerly very abundant in Ireland. One of the most characteristic qualities of the quail is its fighting capabilities. At the same time, there are some species of birds which are on the increase. One of these is the water-rail, which is quite as valuable for the table as snipe.

The President, when inviting members of the Society who took a special interest in this subject, made some remarks, and described the statement of Mr. Robinson as very interesting indeed. He was surprised to hear that the yellow wagtail had so restricted a distribution. With regard to the grey-crested grebe, perhaps its most remarkable characteristic is the peculiar formation of the patella, which extends considerably upwards above the knee-joints.

Rev. Mr. Robinson asked permission to interrupt the President in order to state that he sent a grebe to Dr. Haughton, of Dublin, which died shortly afterwards, and was dissected. Dr.

Haughton appreciated the bird very much, and in dissecting it he was greatly interested with the peculiarity which the President had just spoken of.

The President said that the peculiar formation of which he had been speaking was known long before Dr. Haughton was heard of. Resuming his observations, Dr. Cunningham said he was amused to hear of the fighting qualities of the quail. Concluding his observations, Dr. Cunningham referred to a very interesting species of grass mentioned by Mr. Robinson as occurring at Lough Neagh, and in this connection he paid a becoming tribute to the late Mr. Corry and Mr. Dickson, who, if they had been spared, would have been yet amongst the most eminent botanists in Ireland.

Rev. Dr. Grainger, calling attention to the statement with reference to Dr. Haughton, observed that, of course, Dr. Haughton was too able a scientist not to know that the peculiar formation of the patella of the grebe was not his discovery ; but what Dr. Haughton desired to establish in connection with that fact was that the variation in that particular is attended by variations in the form of the entire bird.

The President then requested Mr. R. L. Patterson to favour the meeting with some observations, the subject being one to which Mr. Patterson paid much attention.

Mr. Patterson expressed his appreciation of the interesting statements made by Mr. Robinson. He was much gratified to find amongst the seven rare birds three that were thoroughly oceanic birds. The long-tailed duck is a very rare bird, and he, in the course of some fifteen years, had met with only three specimens in the Belfast Lough. They are known on the west coast of Scotland, and Mr. Gray, a Scotch naturalist, has published very interesting accounts of their occurrence on the Western Isles. It was, indeed, a novelty that such a thoroughly oceanic bird as the eider duck should have occurred in fresh water. He was not surprised to hear that the scoter duck was found at Lough Neagh, and had often been surprised to hear that it was not seen at that Lough, because it occurs so abundantly in Belfast Lough, sometimes in numbers covering

an enormous area, and the distance from Belfast Lough to Lough Neagh is comparatively short. Mr. Robinson had said that the scoter duck is tame. Well, that is to be accounted for by the circumstance that they are not sought after by the gunners, because of the rank food on which they live. Probably, however, when they become accustomed to the better food which can be had in Lough Neagh they will be more valued by sportsmen, and then probably they will not be so easily approached. Regarding the disappearance of the grey-crested grebe, that is largely, he believed, the result of the mania for egg collecting that takes possession of some persons nowadays. He knew one gentleman who last spring took all the eggs which he found in four grebes' nests. Mr. Patterson then called attention to two species of geese which were recently shot near Comber. They were Antarctic species. He could easily understand that a North-American goose could be found in Lough Neagh, but it was impossible that Antarctic species could have crossed the equator. It was therefore concluded, and correctly, as subsequent inquiries proved, that the two specimens now on the table were escapes. They had escaped from Hillsborough Park. Mr. Patterson concluded by stating that about fifteen months ago a woo-whoop was shot near Lurgan, and a large number of petrels of both species were got recently in the neighbourhood of Toome, their presence there being attributed to the recent severe storm.

The President thanked Mr. Patterson for his interesting remarks, and said that there could be no doubt that the two specimens of geese which were referred to by him were Antarctic.

Rev. Mr. Lett, who was allowed to speak, although not a member, mentioned that he had often seen wild swans to the number of 500, on Lough Gullion, in County Armagh.

Mr. Mulholland agreed with Mr. Robinson that the wagtail is becoming scarce, and he had observed the fact with reference to the common black wagtail. The lark, quail, and partridge are also becoming very scarce. He ascribed the fact to an increase in the number of starlings in the country, which birds usually destroy the nests of the ground birds.

5th February, 1883.

The President, Dr. Cunningham, in the Chair.

Professor Meissner, Ph.D., read a paper on

HEATHEN REMAINS IN CHRISTIAN CHURCHES.

The early Christians did not all at once renounce all Jewish and heathen customs and beliefs. For a long time the Church celebrated two masses on the first of January, the first the mass for circumcision day, and the second a *missa ad prohibendum de idolis*. Many heathen temples were converted into Christian churches, and places which were considered holy by the Gentiles were chosen as the sites of churches. Constantine the Great built a church in the plains of Mamre, on a spot holy alike to Jew, Gentile, and Christian. St. Boniface built a chapel out of the oak of Thor, at Hofgeismar. Wittekind, Duke of the Saxons, built churches on every spot on which, before his conversion, he had erected idols. The Cathedral of Cordova stands on a spot which has been succesively occupied by a heathen temple, a Christian church, and a mosque.

Many heathen remains have been found at restorations embedded in the Christian structure. At S. Martin, near Trèves, a Roman altar ; at Gersthoven, near Augsburg, two statues of Mercury ; on the Domberg, near Augsburg, sacrificial knives and vessels ; at Compton Dando, Somerset, an altar of Venus is walled into the east end of the parish church ; at the church of S. Mathias, at Trèves, an image of Venus or Diana stood for centuries in the porch ; the custom of the people was

to fling a pebble at the image on entering the church. Subsequently this image was hung in chains in the churchyard, and is now to be seen in the diocesan museum.

The early Eastern Church anxiously removed all vestiges of idolatry from buildings dedicated to Christian worship, but the Western Church allowed a greater latitude. S. Augustine, in a letter to Publicola (No. 154, ed. Vulg., No. 47, ed. Bened.), justifies the retention of heathen works of art by reference to Joshua vi., 18, 19. To avoid any temptation to man-worship, symbols were chosen to represent the persons of the Trinity; a hand reaching out of the clouds for God the Father, the Agnus Dei for God the Son, the dove for the Holy Ghost. Heathen symbols, such as the Phenix, the Unicorn, the Sirens, the Basilisk, became Christian symbols with a new and deeper meaning. Medieval art and poetry developed this kind of symbolism with special predilection. The fabulous history of the Unicorn as a symbol of the incarnation and death of Christ, became one of the most frequent sculptural ornaments of our churches.

The well-known reference to the Cumæan Sybil in the fourth Eclogue of Virgil had early struck the Christians as greatly resembling the prophecy of Isaiah. The Sybils were introduced into the Christian tradition as prophetesses, as early as the second century. They even are appealed to in one of the most solemn hymns of the Church, the *Dies irae.* They are found frequently represented holding in their hands the instruments of the Passion, at Badninch and Ugborough in Devonshire, on the panels of the Rood-screen; and at Auch in the Pyrenees, on the stalls, and in a painted window.

Of heathen origin are, likewise, the oldest images of the Saviour. The oldest type is the Jupiter type; next the Helios-Mithras type, from which the halo (originally a attribute of Kings and Gods), has been imported into Christian art, the crossed nimbus being reserved for the figure of Christ. The last type is the Semitic, which has been finally accepted as the traditional portrait of Christ. This type we can trace distinctly back to the famous miraculous image of Edessa. Dr.

Meissner here sketched the subsequent history of this image at Constantinople, Rome, and Genoa.

Gems, on which are carved heathen deities and scenes from heathen mythology, have been frequently used in the ornamentation of shrines, processional crosses and other church furniture, such as the Theofanu-cross, and the cross of Mathildis at Essen, the shrine of S. Elizabeth at Marburg, the pulpit at Aix-la-Chapelle. As late as the 17th century a similar ornamentation was employed in the sacramental plate of the Protestant Church at Hermannstadt. The use of secular dyptichs as covers for mass and gospel-books is well known.

Holy wells were frequently enclosed in churches, and their real or supposed miraculous powers hallowed by the church. Most of these have been now covered up—*e.g.*, Strassburg, Würzburg, Freiburg in Baden, Carlisle. On the enclosure of the well in Ratisbon Cathedral are sculptured Christ and the Samaritan woman.

Idols were mostly destroyed, but the few remaining ones are of the greatest interest. Chief of all, the famous Irminsul which Charlemagne overthrew in 772 at Eresburg, and is now in the cathedral at Hildesheim. After the dissolution of the Abbey of Corvey, this idol was removed to its present position. A heathen idol, formerly in the Conventual Church of Colbatz in Pomerania, is now in the Vaterländisihes Museum at Berlin. Also the Wendic idol, the Püsterich, has been removed to the Museum at Sondershausen. But the old idol Swantevit still occupies its place in the east end of the Church at Altenkirchen, in the island of Rügen. The brazen serpent, which Archbishop Arnulf brought, in the year 1001 from Constantinople, fondly believing it to be the brazen serpent which Moses erected in the wilderness, still occupies its old place in the Church of S. Ambrogio at Milan. It most probably belonged to a temple of Aesculapius, or was, as some think, an Egyptian talisman of the third or fourth century.

12th February, 1884.

The President, Dr. Cunningham, in the Chair.

Mr. William Hancock, F.R.G.S., of the Chinese Imperial Customs Service, read a Paper on

NORTH FORMOSA.

The lecturer sketched the leading geological features of the district, describing the remarkable steam geysers and extinct craters which he had investigated during his residence on the island. Comparison was made between the flora of North Formosa and other parts of China, and a description was given of the plants from the sea level to the mountain summits, with special mention of the extraordinary variety of ferns, of which Mr. Hancock collected nearly 70 species in one glen alone, and no less than 129 within a radius of twenty miles round the treaty port of Tientsin. Amongst these the rare Dipteris Wallichii was discovered, which, the lecturer observed, was closely allied to the extremely rare Dipteris Horsfieldii discovered by Dr. Horsfield in only four places in Java during fourteen years' travel, and specially referred to and figured by Wallace in his Malay Archipelago. The typhoons and earthquakes of Formosa were discussed, mention being made of the earthquake of December, 1867, when the sea ran out of Kelung Harbour, and, returning, swept the junks on to the houses, and when the towns of Kelung Kimpaoli, Pachena, and Tientsin were partially ruined, and many hundred lives were lost. Various interesting varieties of birds were described, including the exquisite Pericrocotus

brevirostris, of Hindostan. The reptiles and insects were compared with those of Hainan and the East Indies, and attention was drawn to the remarkable marine fauna on the east coast of the island, which, in consequence of the high temperature of the Kurosiwo current, exhibits close affinity to that of Singapore and other tropical seas. The variations of climate were mentioned, and the intense heat of Hainan was described.

In conclusion, the lecturer said that the impression left on his mind was a mixed and rather sad one. He had been amongst a people whose days are numbered, a people who show various kind and amiable traits of character, but whose natural temperament, even were they disposed to work, seems unfitted for the systematic toils of civilised nations ; whose ignorance and simplicity permit them to barter away their noble forests for a mess of pottage, who are steeped in poverty and ignorance, the constant dupes of unscrupulous and mercenary neighbours, the victims of strong passions ; without friends, without help, without sympathy, children of the present hour.

4th March, 1884.

The President, Dr. Cunningham, in the Chair.

Mr. F. W. Lockwood read a Paper on

SANITARY PROTECTION ASSOCIATIONS.

This paper was the legitimate outcome of one by Mr. W. Gray, C.E., M.R.I.A., in the previous session, upon the sanitary construction of houses, and described the operation of the various societies formed in England and Scotland to protect householders against the evils described in Mr. Gray's paper.

The principle of all these societies may be briefly described as being similar in nature to the Steam Boiler Protection Association, viz :—to secure to the members, for a moderate annual subscription, the benefits of inspection and report, with disinterested advice, and subsequent periodic inspection.

The *modus operandi* is generally as follows :—A person wishing to become a member applies at the office, pays down a small entrance fee, and a sum, generally £1 1s. 0d., as annual subscription, and arranges for an inspection of his house by the engineer of the Association. When this takes place, it is desirable that the member should have a plumber, one who knows the house being preferred, in attendance, and that the main drain from the house should be opened at some convenient place. These are the only expenses beyond the subscription, which are unavoidable, any further outlay is entirely at the discretion of the owner. The engineer examines all the closets, pipes, traps, cisterns, &c., and tests the drains under the house

by pouring paraffin or other strong smelling volatile substance down them from the roof. In a large number of cases this test reveals the existence of one or more defective joints through which sewer gas may make its way inside the house ; and in most houses built previous to the last eight or ten years, the examination discloses faulty construction or arrangements in one or other particular. In due time the member receives a detailed report, and a sketch plan of the house, showing the position of the drains, closets, &c., with suggestions, if needed, for improvements. These the member can make or not as he may choose, and by whom he may choose :—the Association does not undertake them, or derive any profit from the works. These suggestions further distinguish between the more or less necessary alterations. Should the member decide upon making changes, the engineer will visit them during progress, or on completion, and advise as to their efficiency. No less important than to have the sanitary arrangements of a house set right as described above, is it to be assured that they remain so. Here it is that the advantage of continuous membership is to be found. During each year a person remains a member of the Association he is entitled to at least one visit and inspection as thorough as the first, to ascertain whether any of the complicated arrangements of modern sanitation have got out of order through decay, settlement of pipes, action of rats, weather, or other causes, thus giving the member a guarrantee not merely his house has been put into a fairly healthy condition, but that it remains so.

Should a member require inspection of more than one house, he pays for each a separate annual subscription, but no further entrance fee. Special buildings, or those at a distance, are dealt with according to arrangement, or by a tariff fixed upon terms as moderate in proportion as those above.

Two simple arguments may be given in favour of such associations.

The first is that of example : they have already been instituted in Edinburgh, London, Birmingham, Liverpool, Glasgow, Newcastle, Bradford, Brighton, Dundee, Wolverhampton, Gloucester, Cheltenham, and Bedford, which, as their scope takes

in a large radius of the country round each of these places, cover no inconsiderable area of the more populous parts of Great Britain. The Associations in these places embrace in their membership a large number of hospitals, banks, schools, asylums, and country mansions, in addition to private dwelling-houses ; their popularity is rapidly increasing, and their sphere of usefulness widening. Medical men especially have been prominent in seeking the benefit of the inspection for their own residences.

The second argument may be drawn from the facts told in the reports of the Associations themselves. The London report for 1883, for instance, shows that their engineers had examined during the year 404 houses. Nine of these were found to have their drains entirely closed up, and *no connection whatever with the main sewer*, all the foul matter sent down the sinks and soil pipes simply soaking into the ground under the basement of the houses. In ninety-three houses, or twenty-three per cent., the overflow pipes from the cisterns were led direct into the drains and soil pipes, allowing sewer gas to pass up them and contaminate the water in the cisterns, and in many cases to pass freely into the houses. In seventy-nine houses, or about twenty per cent., the soil pipes were found to be leaky, allowing sewer gas, and in many cases liquid sewage, to escape into the houses. In two hundred and sixty-nine houses, or about sixty-seven per cent, the waste pipes from the baths and sinks were found to be led direct into the drains or soil pipes (presumably, doubtless, with the usual inadequate S trap), thus allowing the possibility of sewer gas passing up them, instead of these pipes being led *outside* the house, and made to discharge over trapped gullies as they should be.

A very similar condition of things is revealed by an examination of the reports of the Edinburgh Association. Of the houses inspected by its officers for the first time, seventy-five per cent. were found to have the cistern overflows connected with the foul or drainage system, which practically means that in each of these cases a direct channel existed for the introduction of poison into the house, arranged in a manner which did not

even admit of being partially guarded by the oldfashioned, and too often inefficacious, trap of the ordinary plumber. Other defects were found to exist in very much the same proportion as recorded in the case of London.

A paragraph from the report of one of the annual meetings of the Edinburgh Association describes a principle of action on the part of most of these Societies, well calculated to recommend them to the confidence of the public. It says "the Association did not exist for making employment for plumbers. They advised people, told them what was wrong, and left them to employ whoever they liked. They had also guarded against touting for the employment of patents. The number of patents which claimed to put sanitary matters right was legion, and if they were to take up any one of these, they would raise a pretty nest of hornets about their ears for overlooking the special patents of others."

In conclusion, it may be pointed out that these Associations occupy an intermediate position between that period of darkness when prince and peasant were by the universality of ignorance alike exposed to a foe as deadly as it was treacherous, and that happy time when, by the enlightened action of municipal authority, such a thing as an unsanitary house shall be an impossibility. During that interval, which, if human nature does not radically change, bids fair to be a long one, these sanitary associations are likely to fill a place the value of which can hardly be over-estimated.

4th March, 1884.

The President, Dr. Cunningham, in the Chair.

Mr. Robert Young, C.E., read a Paper on

STONE IMPLEMENTS AND FRAGMENTS OF POTTERY,

Which he had lately procured from the State of Illinois, U.S.A.

The writer described the usual character of the prehistoric earthworks which are so numerous in the great central States of North America, specially in those drained by the Ohio River, and in which stone implements are usually found associated with evidences of human burial, making it evident that they are the analogues of the tumuli and cairns of this country.

He compared the implements which are composed of chert, quartz, and obsidian, with those most nearly resembling them in the Benn collection laid beside them on the table, and pointed out their peculiarities. None of the arrow-tips in this collection, however, are finished with the very singular spiral curve which characterizes some of those he had obtained from Ohio, and presented to the Museum in 1879. He offered what he had now shewn to add to the former gifts.

In conclusion, he said the Society was very anxious that it should be known throughout Belfast and Ulster generally, that they would be very glad to receive and exhibit, not only specimens of ancient Irish weapons and implements, but also those of aboriginal tribes in foreign lands, with many of which they knew that friends of this Society had business connexions. If

a little trouble was taken in this direction by merchants, shipowners, and captains, in a few years they might hope to have, in addition to their already most extensive and valuable collection of native antiquities, an interesting and instructive series of objects of comparative archæology, such as the increasing interest of this subject demands.

1st April, 1884.

Professor EVERETT in the Chair.

ROBERT LLOYD PATTERSON, Esq., J.P., read a Paper on

MIGRATORY BIRDS.

MR. PATTERSON said, among the many beautiful objects with which nature has so richly endowed this world, there are none more attractive than birds. To the lovers of nature there is no more interesting occupation than to observe their elegant forms, beautiful colours, and graceful movements, while their varied habits and the periods of arrival and departure of those species that are migratory, invest the study with a fascination all the greater on account of the mystery in which some of these movements are still involved. The number of different species of birds hitherto recorded as inhabiting the entire globe amounts to about 6000; those inhabiting Europe to 624, and those found in the British Islands to 376; but of these 165 are only occasional visitors, thus reducing the number of regular British birds to 211 species. Some of these have been obtained in England but not in Ireland, and *vice versa*. Of the migratory species the larger number are summer migrants, coming in the spring to build their nests and rear their young, and departing in the autumn to spend the winter in warmer climes. Others again come in the late autumn or early winter, and leave in spring. There is almost an infinite variety in the size, form, and habits of birds. The disparity between the largest bird, the ostrich, and the smallest, the humming bird, is almost as great as that between an elephant and a mouse. The mutual adaptation of form and habit all through the animal

creation is wonderful, but in no department is it more marked than in birds. This was illustrated by the heron, the curlew, the swallow, and raptorial birds, such as eagles, hawks, and owls. The short-eared owl is an occasional but erratic migrant to Ireland in winter. The present season is a great owl year. Mr. Darragh, the excellent curator of our Museum, has got about twenty specimens, and Mr. Sheals about six or eight. After treating of the family of vultures, and of the adaptation of water-fowl to their modes of life, the writer stated that the variety of colour among birds is no less striking than that of form and size. As with tropical plants, so among tropical birds are to be found the most gorgeous in colour as well as the richest in plumage. The variety of movement, too, is considerable. Of the 211 species of British birds, 128 are permanent residents, 52 summer, and 31 winter migrants. The numbers of many of the resident species are largely reinforced by migration. The causes that induce birds to undertake long, fatiguing, dangerous journeys over thousands of miles of sea and land are principally their search for food and their natural desire to reproduce their species under the most favourable conditions. The writer then dealt with the habits of the more conspicuous summer migrants—the barn swallow, the house martin, the sand martin, and the swift, afterwards mentioning the wheatear, whinchat, and stonechat. The warblers are very unobtrusive, and so shy in their habits as seldom to be noticed. The most distinguished member of this family is the nightingale, which sings during the day as well as the night. Sometimes an extraordinary "rush" of some species of birds occurs, and it may not be seen on migration again for some years. Such a migration of golden-crested wrens, one of the smallest of British birds, occurred in 1882. The writer then treated of the habits of the corncrake, the cuckoo, and those birds that from a summer home farther north come to our latitudes as a comparatively temperate climate in which to spend the winter. In consequence of the large extent of coast line, in comparison with the superficial area, in Ireland the *avifauna* is especially rich in marine species, as compared with France

and other less maritime countries. As to the general question of the migration of birds, it has been argued that the lines of flight followed by birds in migration, especially when crossing seas, are the same lines that were taken by the remote ancestors of these same birds ages ago, when it is believed much land was above water which is now submerged. It has been further argued that the habit of taking particular lines of flight has continued for thousands of years, and still exists, notwithstanding the altered physical and geographical conditions. Plausible and even attractive as that theory is, the essayist could not coincide with it. The theory that the flight of birds in migration ordinarily takes place at high elevations is supported by the fact that it is only in dark or cloudy weather that migration on a large scale is observable. It has been noticed that a stream of migration seemed suddenly to stop when the moon rose. From its geographical position, Ireland is out of the tract of migration. The uncertainty still attaching to some of the migratory movements of birds invests them with an interest, indeed we may say a charm, peculiarly their own, and the study is one which, while it tends to the development of both the observant and the reflective faculities, elevates the mind, and leads us to regard with renewed admiration the mysterious ways of nature.

BELFAST
Natural History & Philosophical Society.

Officers and Council of Management for 1884-5.

President:

PROFESSOR CUNNINGHAM, M.D.

Vice-Presidents:

JOHN ANDERSON, Esq., F.G.S.
ROBERT MacADAM Esq.
Prof. J. D. EVERETT, M.A., F.R.S.
THOMAS WORKMAN, Esq.

Treasurer:

JOHN BROWN, Esq.

Librarian:

THOMAS WORKMAN, Esq.

Secretary:

WILLIAM H. PATTERSON, M.R.I.A.

Council:

PROFESSOR CUNNINGHAM, M.D.
JOHN ANDERSON, Esq., F.G.S.
ROBERT MacADAM, Esq.
PROFESSOR J. D. EVERETT, M.A., F.R.S.
THOMAS WORKMAN, Esq.
JOHN BROWN, Esq.
JAMES WILSON, Esq.
PROFESSOR E. A. LETTS, Ph.D., F.R.S.E.
JOSEPH JOHN MURPHY, Esq., F.G.S.
ROBERT LLOYD PATTERSON, Esq.
WILLIAM H. PATTERSON, Esq., M.R.I.A.
PROFESSOR PURSER, M.A.
WILLIAM SWANSTON, Esq., F.G.S.
JOSEPH WRIGHT, Esq., F.G.S.
ROBERT YOUNG, Esq., C.E.

SHAREHOLDERS.

[*Denotes holders of three or more Shares.]

Allen, W. J. C., J.P. (Representatives of), Faunoran, Greenisland.
Andrews, Michael (Representatives of), Ardoyne, Belfast.
Andrews, Thomas, M.D., F.R.S., &c., Fortwilliam Park, do.
Andrews, Samuel, J.P., Victoria Street, do.
Archer, S., J.P. (Representatives of), Wellington Place, do.
Anderson, John, J.P., F.G.S., Hillbrook, Holywood.
*Alexander, James, J.P. (Represenatives of), Holywood.

*Bateson, Sir Thomas, Bart., M.P., J.P., D.L., Belvoir Park, Belfast.
*Batt, Thomas G. (Representatives of), Belfast.
Bland, Robert Henry, Lisburn.
Bottomley, Henry H., Garfield Street, Belfast.
*Bottomley, William, J.P., do.
Brett, C. H., Chichester Street, do.
Bristow, James R., Northern Bank, do.
Barbour, James, Falls Foundry, do.
Boyd, William, Blackstaff Mill, do.
Boyd, W. S., Donegall Quay, do.
Brown, John Shaw, J.P., Bedford Street, do.
Brown, John, Bedford Street, do.
Brown, William K., Rushmere, do.
Burden, Henry, M.D., Alfred Street, do.
Burnett, John R., Gamble Street, do.

*Campbell, James (Representatives of).
Campbell, John, Lennoxvale, Belfast.
Connor, Charles C., White Linen Hall, do.
Carlisle, James, J.P. (Representatives of), Donegall Street, do.
Carson, John, Church Lane, do.
*Charley, John (Representatives of), Finaghy, do,

*Clermont, Lord, Ravensdale Park, Newry.
Coates, Victor, Rathmore, Dunmurry.
*Charters, John (Representatives of).
Crawford, William, Calender Street, Belfast.
Cuming, James, M.D., Wellington Place, do.
Calwell, Alexander McD., College Square North, do.
Cunningham, Robert O., M.D., F.L.S., Queen's College, do.
Clarke, Edward H., Elmwood,

Darbishire, James M., Lombard Street, do.
*Donegall, Marquis of, K.P., &c. (Representatives of), London.
Drennan, Dr., Chichester Street, Belfast.
*Drummond, Dr. James L. (Representatives of), do.
Duffin, Charles, J.P., Waring Street, do.
Dunville, William, J.P. (Representatives of), Calender St., do.
*Downshire, Marquis of, Hillsborough Castle, Hillsborough.
Dixon, Thomas S., York Street, Belfast.

Emerson, William, Donegall Quay, do.
Everett, J. D., M.A., D.C.L., F.R.S., Queen's College, do.
Ewart, William, J.P., M.P., Bedford Street, do.
Ewart, W. Quartus, Bedford Street, do.

*Fenton, Samuel G., J.P. (Representatives of), do.
Ferguson, Henry, M.D., Fisherwick Place, do.
Forsythe, R. H., Holywood.
Finlay, William Laird, Windsor, Belfast.
Finlay, William Laird, jun., Royal Avenue, do.
Fuller, Professor George, Queen's College, do.
Fagan, John, F.R.C.S.I., Glengall Place, do.

Garrett, Thomas (Representatives of), Gamble Street, do.
*Getty, Edmund (Representatives of), do.
Girdwood, H. Mercer, Broughton Maxwell, Manchester.
Gordon, Alexander, M.D., Howard Street, Belfast.
Gordon, R. F., J.P., D.L. (Representatives of) Florida Manor, Killinchy.

*Grainger, Rev. John, D.D., Broughshane, Ballymena.
Gray, Robt. (Representatives of), College Square North, Belfast.
Gordon, Robert W., J.P., Falls Road, do.
Greer, Thomas, J.P., M.P., Seapark, Carrickfergus.
Gray, William, C.E., M.R.I.A., Mount Charles, do.

Hogg, John, Academy Street, do.
*Hamilton, Hill, J.P. (Representatives of), Mount Vernon, do.
Hancock, John, J.P., Lurgan.
Henderson, Robert (Representatives of), High Street, Belfast.
*Henry, Alexander, Manchester.
*Herdman, John (Representatives of), College Sq. North, Belfast.
Hind, James, Durham Street, do.
Hind, John, J.P., Durham Street, do.
Hind, John, jun., College Street South, do.
Heyn, James, A.M., Ulster Chambers, Waring Street, do.
*Houston, John B., J.P., D.L., Orangefield, do.
Herdman, John, J.P., Carricklee House, Strabane.
Hamilton, Sir James, J.P. (Reps. of), Waring Street, Belfast.
Harland, Edward J., J.P., Queen's Island, do.
Hodges, John F., J.P., M.D., F.C.S., Queen's College, do.
Hyndman, Hugh, LL.D., Waring Street, do.
Henderson, W. D. (Representatives of), Victoria Street, do.
Henderson, James Alexander, J.P. (Reps. of), Donegall Street, Belfast.
Holford, T. & A., Cern Abbas, Dorsetshire.

Jackson, Thomas, C.E., Corn Market, Belfast.
Jaffé, John, Donegall Square South, do.
Jaffé, Otto, Donegall Square South, do.
*Johnson, Sir William G., J.P., D.L., College Sq. North, do.
Johnston, Samuel A., Jennymount Mill, do.

Kennedy, James, Falls Road, do.
Keegan, John J., High Street, do.
*Kinghan, Rev. John, Deaf and Dumb Institution, do.

Lanyon, Sir Charles, J.P., The Abbey, Whiteabbey.
Lepper, F. R., Ulster Bank, Belfast.
Lakin, Mrs. John, Tamworth.
Letts, Professor E. A., Queen's College, Belfast.
Lytle, David B., Victoria Street, do.

*Macrory, Adam J. (Representatives of), Ulster Chambers, do.
Mitchell, W. C., J.P., Tomb Street, do.
*Mitchell, George T. (Representatives of), do.
Montgomery, Thomas, J.P., Ballydrain, do.
Moore, James, J.P., Dalchoolin, Craigavad.
*Mulholland, Andrew, J.P., D.L. (Representatives of), Belfast.
*Mulholland, J., J.P., D.L., M.P., Ballywalter Park, Ballywalter.
Mullan, William, J.P., Victoria Street, Belfast.
Murney, Henry, J.P., M.D., Donegall Square East, do.
Musgrave, James, J.P., Ann Street, do.
Murray, Robert (Representatives of), Arthur Street, do.
*Murphy, Joseph John, 2, Osborne Park, do.
*Murphy, Isaac James, Armagh.
Musgrave, Henry, Ann Street, Belfast.
Musgrave, Edgar, Ann Street, do.
Moore, James, Donegall Place, do.
*M'Calmont, Robert, London.
*M'Cammon, Thomas, Dublin.
M'Clure, Sir Thomas, Bart., V.L., M.P., J.P., Belmont, Belfast.
M'Cance, Finlay, J.P., Suffolk, Dunmurry.
*M'Cance, J. W. S. (Representatives of), Suffolk, Dunmurry.
*M'Cracken, Francis (Representatives of), Donegall St., Belfast.
MacAdam, Robert, College Square East, do.
MacIlwaine, Mrs. Jane (Representatives of), do.
MacIlwaine, Rev. Canon, D.D., M.R.I.A., Mount Charles, do.
*MacLaine, Alex., Queen's Elms, Belfast.
M'Gee, John G. (Representatives of), High Street, do.
M'Neill, George Martin, Beechleigh, Windsor, do.

Neill, John R., Queen's Arcade, do.

Patterson, E. Forbes, High Street, Belfast.
Patterson, Mrs. M. E., Ardmore Terrace, Holywood.
Pim, Edward W., High Street, do.
Pim, George C., (Representatives of), Corporation Street, do.
*Pirrie, John M., M.D. (Representatives of), do.
Purdon, Thomas Henry, M.D., Wellington Place, do.
Patterson, William R., Lower Crescent, do.
*Patterson, R. Lloyd, J.P., Corporation Street, do.
Patterson, William H., M.R.I.A., High Street, do.
Purser, Professor John, M.A., Queen's College, do.
Porter, Drummond, Waring Street, do.
Patterson, Richard, High Street, do.
Patterson, David C., Corporation Street, do.

Riddel, William, Ann Street, do.
Rowan, John, York Street, do.
Ritchie, W. B., M.D., J.P., The Grove, do.
Ross, William A., J.P. (Representatives of), Clonard, Falls Road, Belfast.
Rea, John Henry, M.D., Great Victoria Street, Belfast.
Robertson, William, J.P., Bank Buildings, do.
Robinson, John, York Street, do.

Simms, F. B., 39, Prospect Terrace, do.
Sinclair, Thomas, M.A., J.P., Tomb Street, do.
Suffern, John, Windsor, do.
Suffern, William, Windsor, do.
Steen, Dr. Robert, Ph.D., Academical Institution, do.
Smyth, John, jun., M.A., C.E., Milltown, Banbridge.
Smith, F. Chaloner, Sandymount.
Swanston, William, F.G.S., King Street, Belfast.

*Tennent, R. J., J.P., D.L. (Representatives of), Rushpark, do.
*Tennent, Robert (Representatives of), Rushpark, do.
Thompson, Robert, J.P., Fortwilliam Park, do.
Thomson, Charles, College Gardens, do.

*Thompson, James, J.P., Macedon, Whiteabbey.	
*Thompson, Nathaniel (Representatives of).	
*Thompson, William (Representatives of),	Belfast.
*Turnley, John (Representatives of),	do.
Torrens, James, J.P., Wellington Place,	do.
Valentine, James W., Custom House Square,	do.
Valentine, G. F., The Moat, Strandtown,	do.
Workman, John, J.P., Windsor.	
Wilson, James, Old Forge, Dunmurry.	
Walkington, Thomas R., Waring Street,	Belfast.
Workman, William, Corporation Street,	do
Workman, Rev. R., Newtownbreda.	
Wilson, John K., Donegall Street,	do.
*Wilson, Robert M.	
*Workman, Thomas, Bedford Street,	Belfast.
Wallace, James, Ulster Bank,	do.
Ward, Fras. D., J.P., Bankmore,	do.
Wright, Joseph, F.G.S., Donegall Street,	do.
Workman, Charles, M.D., Balmoral Terrace,	do.
Workman, Rev. R., Glastry, Kirkcubbin.	
Walkington, D. B., Windsor,	do.
Young, Robert, C.E., Donegall Square East,	do.
Young, Robert M., Donegall Square East,	do.

HONORARY MEMBERS.

Robinson, Hugh, Donegall Street,	Belfast.
Stewart, Samuel A., F.L.S., North Street,	do.
Tate, Professor Ralph, F.G.S., Adelaide, South Australia.	

ANNUAL GUINEA SUBSCRIBERS.

Bruce, James, J.P., Calender Street,	Belfast.
Corry, James P., J.P., M.P., Dunraven, Windsor,	do.

Craig, James, J.P., Calender Street,	Belfast.
Corry, Thomas H., Benvue, Malone,	do.
Collier, W. F., LL.D., Belfast Academy,	do.
Carr, James, Ulster Bank,	do.
Dinnen, John, Chichester Street,	do.
Dunville, Robert G., D.L., J.P., Calender Street,	do.
Glass, James, Bedford Street,	do.
Glover, G. T., Ballymacarrett,	do.
Graham, O. B., J.P., York Street,	do.
Liversedge, H. J., Lagan Foundry,	do.
Loewenthal, J., Linenhall Street,	do.
Lynn, William H., C.E., Calender Street.	do.
Matier, Henry, J.P., Clarence Place,	do.
Milligan, S. F., 1, Royal Terrace,	do.
Moreland, John H., Co. Down Co., Donegall Square,	do.
Mulholland, J. R. T., J.P.,	do.
Murray, Robert, Corporation Street,	do.
M'Auliffe, George, J.P., Calender Street,	do.
M'Causland, John K., Lennoxvale,	do.
Oakman, Nicholas, Prospect Terrace,	do.
Pring, Richard W., Corn Market,	do.
Redfern, Peter, M.D., Professor Queen's College,	do.
Reade, Robert H., York Street,	do.
Rogers, John, Victoria Street,	do.
Seeds, William, Corn Market,	do.
Stannus, A. C., Chichester Street,	do.
Steen, William, Donegall Quay,	do.
Taylor, Sir David, J.P., Windsor,	do.
Tate, Alexander, C.E , Queen's Elms,	do.
Taylor, John Arnott, M.A., Bridge Street,	do.
Watt, R., Victoria Street,	do.
Wolff, G. W., Queen's Island,	do.
Ward, John, F.G.S., Lennoxvale,	do.
Ward, Marcus J., Bankmore,	do.
Young, Samuel, Talbot Street,	do.

ß. 14.

Report and Proceedings

OF THE

BELFAST

NATURAL HISTORY & PHILOSOPHICAL SOCIETY,

FOR THE

SESSION 1884-85.

BELFAST:
PRINTED BY ALEXR. MAYNE & BOYD, 2 CORPORATION STREET.
(PRINTERS TO THE QUEEN'S COLLEGE.)

1885.

Report and Proceedings

OF THE

BELFAST

NATURAL HISTORY & PHILOSOPHICAL SOCIETY,

FOR THE

SESSION 1884-85.

BELFAST:
PRINTED BY ALEXR. MAYNE & BOYD, 2 CORPORATION STREET.
(PRINTERS TO THE QUEEN'S COLLEGE.)

1885.

CONTENTS.

Belfast Natural History and Philosophical Society.

ESTABLISHED 1821.

SHAREHOLDERS.

1 Share in the Society costs £7.			
2 Shares	,,	,,	cost £14.
3 Shares	,,	,,	cost £21.

The Proprietor of 1 Share pays 10s. per annum ; the proprietor of 2 Shares pays 5s. per annum ; the proprietor of three or more Shares stands exempt from further payment.

Shareholders only are eligible for election on the Council of Management.

MEMBERS.

There are two classes, Ordinary Members, who are expected to read Papers, and Visiting Members, who, by joining under the latter title, are understood to intimate that they do not wish to read Papers. The Session for Lectures extends from November in one year till May in the succeeding one. Members, Ordinary or Visiting, pay £1 1s. per annum, due first November in each year.

Each Shareholder and Member has the right of personal attendance at all meetings of the Society, and of admitting a friend thereto ; also of access to the Museum for himself and family, with the privilege of granting admission orders for inspecting the collections to any friend not residing in Belfast.

Any further information can be obtained by application to the Secretary. It is requested that all accounts due by the Society be sent to the Treasurer.

The Museum, College Square North, is open daily from 12 till 4 o'clock. Admission for Strangers, 6d each. The Curator is in constant attendance, and will take charge of any Donation kindly left for the Museum or Library.

BELFAST

Natural History and Philosophical Society.

ANNUAL REPORT, 1885.

The Annual Meeting of the Shareholders of the Society was held on the 14th May, 1885, at three o'clock, in the Boardroom of the Museum, College Square North. The following were present:—Professor Cunningham, M.D.; Messrs. R. L. Patterson, J.P.; F. D. Ward, J.P.; James Henderson, W. H. Patterson, *Hon. Secretary*; John Brown, *Hon. Treasurer*; Robert Steen, Ph.D.; William Swanston, John Hind, Jun.; and Joseph Wright.

On the motion of Mr. Wright, seconded by Mr. Henderson, the chair was taken by Mr. R. L. Patterson.

The Hon. Secretary (Mr. W. H. Patterson) having read the advertisement calling the Meeting, submitted the Annual Report, which was as follows:—

The Council of the Belfast Natural History and Philosophical Society have now to present to the Members their Report of the working of the Society during the year now ended.

The Winter Session was opened on November 4th, 1884, with a paper on "The Construction and Use of Induction Coils," by Mr. John Brown. The second paper was read on the evening of December 2nd, by Mr. Robert Young, on "Old Japanese Art," and was illustrated by a series of very fine bronzes and other specimens, lent for the occasion by Mr. Henry Matier, and other gentlemen. The next paper was read on January 6th, 1885, by Mr. James Musgrave, on "A recent visit to America, including the Yellowstone Park and Colorado." The next paper was read on February 3rd, by Mr. Thomas Workman, the title was "Eastern Reminiscences." The paper

for the next evening was read by Mr. John H. Greenhill, on the 3rd March, the subject was "Electric Lighting and Transmission of Power by Electricity." The attendance on this occasion was so large that many persons were unable to gain admittance to the lecture-room; Mr. Greenhill, therefore, kindly consented to repeat the lecture. This was done on Thursday, the 5th of March, before a very numerous audience. The next evening of meeting was March 24th. This was extra to the programme arranged at the commencement of the Session. The readers were Mr. John Brown, who made a communication on "A Stalactite formed by a Vapour;" and Mr. Wm. Workman, who read a paper on "The Ventilation and Heating of Churches and Drying-rooms." The last paper of the session was read by the Rev. Robert Workman, on "Land Tenure and Culture in Ancient Ireland," on April 14th.

The work of re-arranging the Museum collections has, during the past year, been confined to the extensive series of mineral specimens. This valuable collection has been classified according to the system adopted in "Dana's Manual of Mineralogy," and, with a few exceptions, each specimen has been furnished with a label stating name and locality. Some of the minerals recently received from the British Museum have been inserted into their proper places, and it is intended that the remainder shall in like manner be incorporated with the general collection. This will have the undesirable effect of still further increasing the present overcrowding; but in the absence of additional cases there is no more satisfactory method of displaying these specimens, which include several noteworthy additions to the existing stock.

A list of donations to the Museum, and of reports and other publications for the Society's library, is to be printed with the present Report. The Council would thank the various donors for their valuable gifts, and would call particular notice to the series of Eastern weapons and works of ornament, presented by Captain Robert Campbell, of the "Slieve Donard." The members will recollect that in the previous years Captain Campbell was also a donor of a number of interesting objects, collected by

him while on his voyages at foreign ports. It is by taking an interest in this way of a practical nature in the Museum of the town with which they are connected by birth or residence, that persons can cause local collections to be substantially benefited. The Council would be gratified if other persons who have opportunities would follow Captain Campbell's example.

On Easter Monday the Museum was opened to the public at at charge of twopence for adults and one penny for children, and the attendance was, as usual, very large.

Your Council now retire from office, and this Meeting will be asked to select fifteen Members to form a new Council.

The Belfast Natural History and Philosophical Society, in account with Treasurer. For Year ending 1st May, 1885.

Dr. | **Cr.**

EXPENDITURE.

	£	s.	d.
To Cash paid Insurance Premiums	£11	5	0
,, ,, Printing Report	7	6	0
,, ,, Advertising	4	12	8
,, ,, Printing and Stationery	5	2	10
,, ,, Repairs	4	0	6
,, ,, Tea, etc.	1	0	6
,, ,, Rent till 1st May	25	0	0
,, ,, Collecting Subscriptions	6	6	4
,, ,, W. Darragh, Salary till 1st May	48	0	0
,, ,, S. A. Stewart, Salary till 1st May, less six months' leave	25	0	0
,, ,, Expenses on Easter Monday	7	7	0
,, ,, Coal, Coke, and Gas	14	4	8
,, ,, Postage	2	9	3
,, ,, Small Accounts	3	7	1
To Balance	10	6	9
	£175	8	7

RECEIPTS.

	£	s.	d.
By Balance in hands	£0	17	3
,, Interest on York St. Loan	19	12	9
,, Subscriptions	83	9	8
,, Donations	4	10	0
,, Proceeds of One Share sold	7	0	0
,, Transfer Fees	0	7	6
,, Contribution from Philo-Celtic Society, 1883-84	3	12	6
,, Contribution from Naturalists' Field Club, 1884-5	5	5	0
,, Contribution from Medical Assoc., 1884-5	3	10	0
,, Entrance Fees at door till 1st May	15	11	3
,, Do Easter Monday	31	12	8
	£175	8	7
By Balance	10	6	9

Examined with Vouchers, and found correct,

Wm. H. Patterson, } Auditors.
Samuel Andrews, }

J. Brown, *Hon. Treasurer.*

DONATIONS TO THE MUSEUM, 1884-5.

From The Natural History Museum, South Kensington.
380 specimens of minerals.

From Mr. George Donaldson, Belfast.

Portion of a plank taken out of the barque Rose on her return from the West Indies, and found to be completely perforated by the teredo.

From Charles Murphy, Esq., Rathfriland.

Four ancient querns formed of granite.

From John Moore, Esq., Moore Fort, Ballymoney, and Hawks Bay, New Zealand.

Two skins of Huias (wingless birds) ; one specimen of Jade.

From Joseph Wright, Esq., F.G.S.

A set of fossil sponge spicules from Ben Bulben.

From W. H. Patterson, Esq., M.R.I.A.

Portions of an ancient urn found at Dundrod, County Antrim.

From Captain Robert Campbell, Master of the Ship "Slieve Donard."

Two Malay shields, three Malay spears, one Malay walking-stick, one Japanese walking-stick, one Chinese walking-stick, two Japanese bronze candlesticks, one Chinese opium pipe, one Chinese tobacco pipe, one Chinese fancy dress sword made of cash, one Japanese fancy bowl with lid, three foreign bird skins, one Malay hat as used in the field.

From Rev. W. H. Lett, M.A., T.C.D.

Portions of antlers of deer, found in gravel at Maralin.

From Belfast Naturalists' Field Club.

Ancient boat with square stem and stern, formed out of an oak tree ; found at Lough Mourne, County Antrim, when the lake was drained in 1883.

LIST OF BOOKS RECEIVED, 1884-85.

BATH.—Journal of Microscopy. Vol. 3, part 9, January, 1884; and Rules, January, 1884. *The Editor.*

BELFAST.—Guide to Belfast, &c., by Dr. Esler *The Author.*

Naturalists' Field Club, Proceedings for 1879-80, 1881, 1882. *The Club.*

Jardine's Humming Birds *T. J. Mulligan.*

BERLIN.—Verhandlungen der Gesellschaft für Erdkunde. Band 11, nos. 2, 3, 4, 5, 6, 7, 8, 9, 10, 1884; band 12, nos. 1, 2, 3, 1885. *The Society.*

BOSTON.—Science Observer. Vol. 4, 43, 44, nos. 7, 8, 1884; vol. 4, nos. 9, 10.

Society of Natural History, Proceedings. Vol. 22, parts 2 and 3, 1883-84 *The Society.*

BREMEN.—Abhandlungen vom naturwissenschaftlichen Verein. Band 8, 2nd heft, and band 9, 1st heft, 1884.

BRESLAU.—Zeitschrift für Entomologie; Neue Folge Neuntes Heft, 1884.

BRIGHTON.—Brighton and Sussex Natural History Society, Annual Report, 1884. *The Society.*

BRUSSELS.—Société Entomologique de Belgique. (Comptes Rendus). 1884. *The Society.*

Comptes-Rendu des Séances. Series 3, nos. 44, 45, 46, 1884. *The Society.*

Société Royal de Botanique de Belgique. Bulletin, 1884. *The Society.*

BUENOS AYRES.—Accedemia Nacional de Ciencias en Cordoba (Republica Argentina).

Tomo 6, entrega 2, 3, and 4, 1884.
do. 7, do. 1, 2, and 3, 1884.
do. 8, do. 1, 1885.

BUENOS AYRES.—Boletin de la Accedemia Nacional de Ciencias en Cordoba (Republica Argentina). Tomo 6, entrega 1[a], 1884. *The Academy.*

CALCUTTA.—Memoirs of the Geological Survey.

Palaeontologica Indica. Series x, vol. 3, parts 2, 3, and 4, 1884.

Records. Vol. 17, parts 2, 3, 1884.

Geological Survey of India, Memoirs. Series 6, vol. 1, part 4. The Labyrinthodont, from the Bigoro Group. Series 10, vol. 3, part 5. Mastodon Teeth, from Perim Island.

Series 13, vol. 1, part 4, fascicule 3. Brachiopoda.
Do. 13, vol. 1, part 4, fasciculus 4. do.
Do. 14, vol. 1, part 5, do. 4. The fossil Echinioida.
Do. vol. 21, parts 2 and 3.

Report, vol. 17, parts 4 ; and vol. 18, part 1. *The Survey.*

CAMBRIDGE, U.S.A.—Bulletin Museum of Comparative Zoology. Vol. xi., no. 10, part 3. "Acalephs," 1884.

Museum of Comparative Zoology. No. 2, 3 and 4, 5, 6, 7, 8, and 11 of Geological Series, vol. 1, 1881 to 1884.

Annual Report, 1883-84. *The Museum.*

CARDIFF.—Report and Transactions Naturalists' Society. Vol. 15, 1883. 1884. *The Society.*

DAVENPORT, U.S.A.—Proceedings Davenport Academy of National Science. Vol. 3, part 3, 1879-81. 1883.

Elephant Pipes in the Museum. 1885. *The Academy.*

DANZIG.—Schriften Naturforschenden Gesellschaft.

Neue Folge Sechsten Bandes Erstes Heft. 1884. *The Society.*

DUBLIN.—Royal Dublin Society, Scientific Proceedings.

Vol. 1, series 2, parts 20, 21, 23 and 24, and 25.
Vol. 3, series 2, parts 1, 2, and 3.
Vol. 3, new series, parts 6 and 7.
Vol. 4, do. parts 1, 2, 3, and 4. *The Society.*

EDINBURGH.—Royal Physical Society, Proceedings 1858-59, 1859-60, 1860-61, 1861-62, 1874-75, 1875-76, 1876-78, 1878-79, 1879-80, 1880-81, 1881-82, 1882-83, 1883-84. *The Society.*

ELBERFELD.—Jahres Berichte des Naturwissenschaftlichen Vereins, sechstes Heft. 1884.

EMDEN.—Achtundsechszigster Jahresbericht Naturforschenden Gesellschaft, 1882-83. 1884. *The Society.*

ESSIA.—Essex Field Club, Transactions. Vol. 3, part 8 ; and Appendix, no. 1. *The Club.*

FLORENCE.—Bulletino della Societa Entomologica Italiana. Anno sedicesimo Trimestri, 1 and 2. 1884.

Trimestri, 3 and 4. 1884., and

Atti Anno, 1882 to 1883. *The Society.*

GENOA.—Giornale della Societa di Letture e Conversazioni Scientifiche. Anno 8, fasc. 8 and 9. 1884.

Societa di Letture, &c.

Anno 8, fasciculus 12.

Anno 9, fasciulus 1 and 2, 3, 4 and 5, and 1 Supplement. *The Society.*

GLASGOW.—Proceedings Philosophical Society. Vol. 15, 1883-84. 1884. *The Society.*

Natural History Society, Proceedings. Vol. 2, parts 1 and 2 ; vol. 3, parts 1 and 3 ; Vol. 4, part 1. *The Society.*

GORLITZ.—Naturforschenden Gesellschaft. Vol. 18, 1884.

HAMBURG.—Naturwissenschaftlichen Verein.

Abhandlungen. Vol. 8, parts 1, 2, and 3. *The Society.*

LAUSANNE.—Bulletin de la Société Vaudoise des Sciences Naturelles. 2nd series, vol. xx, no. 90, 1884.

2nd series, vol. 20, no. 9, 1885. *The Society.*

LEIPSIG.—Sitzungsberchte der Naturforschenden Gesellschaft Zehnter Jahrgang, 1883. 1884. *The Society.*

LIVERPOOL.—Museums of Natural History, by the Rev. H. H. Higgins, M.A. *The Author.*

LONDON.—Memoirs of the Astronomical Society. Vol. 48, part 1, 1884. *The Society.*

Journal Royal Microscopical Society. Series 2, vol. 4, parts 3, 4, 5, and 6, 1884; vol 5, parts 1 and 2. *The Society.*

More Leaves from the Journal of the Life in the Highlands, by the Queen. 1884. *The Publishers.*

Proceedings Zoological Society. Parts 1, 2, 3, and 4.

List of Fellows, to June, 1884. 1884. *The Society.*

Illustrations of British Fungi, by M. C. Cook, M.A. 4 vols, and 13 parts, no. 18 to 31. *Lord Clermont.*

Diurnal Birds of Prey, by J. H. Gurney. *The Author.*

Asclepiad, by B. W. Richardson, M.D., F.R.S. *The Author.*

Stoechiological Medium, by J. F. Churchill, M.D. *The Author.*

A Guide to the Mineral Gallery, British Museum, South Kensington. *L. Fletcher.*

MANCHESTER.—Transactions Geological Society, Session 1883-84. Vol. 17, parts 16, 17, and 18. 1884.

Vol 18, nos. 1, 2, 3, 4, 5, 6, and 7. *The Society.*

Medical Chronicle. Vol. 1, no. 1.

MILWAUKEE.—Natural History Society, Proceedings, 1885. *The Society.*

NEW YORK.—Bulletin American Geographical Society. Parts 1, 2, 5, 6, 1884. *The Society.*

Microscopical Society Journal. Vol. 1, no. 2, 1885. *The Society.*

American Geographical Society, Bulletin. No. 3 and 4. *The Society.*

PHILADELPHIA.—Proceedings Academy of Natural Sciences. Parts 1, 2, and 3, January to April, 1884. *The Academy.*

PISA.—Atti della Societa Toscana di Scienze Naturali. Vol. 4, 3 parts, 1884-85 *The Society.*

ROMA.—Atti della R. Accademia die Lincei Anno 281, Serie Tereza. Vol. 18, fascicolo 11, 12, 13, 14, 15, 1884. *The Society.*

Reale Accademia dei Lincei Atti, 3 Series. Vol. 8, Fas. 16 Atti ; 4 Series, vol. 1, Fas. 1, 2, 3, 4, 5, 6, 7, 8, 9. *The Society.*

SONDERSHAUSEN.—Irmischia. No. 1 and 2, 5, 6 and 7, 8, 9, 10, 11, 12. *The Editor.*

STOCKHOLM.—Das Gehororgan der Wirbelthiere. Von Gustaf Retzius. Part 2. *The Society.*

TRIESTE.—Bolletino della Societa Adriatica di Scienze Naturali, Volume Ottavo, 1883-84.

VIENNA.—Mittheilungen des Ornithologischen Vereines, 1 Jahrgang. Nos. 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 1884.

2 Jahrgang. Nos. 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 1885. *The Society.*

Verhandlungen der K. K. Geologischen Reichsanstalt. Nos. 4, 5, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 1884 ; No. 1, 2, 3, 4, 5, 6, 1885. *The Society.*

Verhandlungen der K. K. Zoologish-botanishen Gessellschaft. Band 33, 1884 ; and Band 34, 1885.

Brasilische Suägethiere, 1883. *The Society.*

Verhandlungen der K. K. Zoologishen Reichsanstalt. Nos. 4, 5, 6, 7, 8, 9, 10, 11, 1884. *The Society.*

WARWICK.—Proceedings Warwickshire Naturalists' and Archæologists' Field Club, 1883. *The Club.*

WASHINGTON.—Geological Survey.

Second Annual Report, 1880-81. 1882. *The Survey*

Report of the Commissioner of Agriculture for 1883.

BELFAST

NATURAL HISTORY AND PHILOSOPHICAL SOCIETY,

SESSION 1884-85.

4th November, 1884.

PROFESSOR EVERETT in the Chair.

JOHN BROWN, ESQ., read a Paper on

THE CONSTRUCTION AND USE OF INDUCTION COILS,

Illustrated by Examples and Experiments.

THE reader exhibited a large coil of his own construction, with others of various types made by Mr. John Edgar and Mr. John H. Greenhill. The principles and action of coils, and the advantages of the disc method of building up the secondary were explained, as well as the most efficient disposition of a given amount of secondary on a given magnetic cone.

Some of the uses of the Induction Coil were illustrated by the illumination of a beautiful set of Crookes's tubes lent by Dr. Everett, the firing of submarine mines by the secondary current, etc.

2nd December, 1884.

James Wilson, Esq., in the Chair.

Robert M. Young, Esq., B.A., read a Paper on

OLD JAPANESE ART.

Mr. Young divided his paper into different sections. The first was devoted to a short sketch of the history of Japan from the time of the Emperor Jimmu, 660 B.C., to the year 1868, when the country was opened to foreigners, and that marvellous series of changes was inaugurated which has transformed the country from being the most backward to the position of the most civilised and enterprising State in the whole of Asia. The lecturer then proceeded to treat of the feudalism which formed so curious a part of the internal economy of Old Japan. He showed that it was almost identical with the military feudalism prevalent in mediæval Europe. The daimio, or baron, was then described. His territory and castle, with the dwellings of his vassals, the samurai, were shown completely to resemble the strongholds of the middle ages, as depicted in the pages of Froissart and Scott. The outline of the most popular Japanese tale of chivalry, the History of the 47 Ronin, was given to show what loyalty and devotion were displayed by the retainers to their lord in critical times, death being always preferred to dishonour.

The swords of the various periods were described in detail, and some interesting facts given of the etiquette practised with regard to that national weapon. A quotation was given from the "Romance of Prince Gengi," written by a learned Japanese

lady in the 10th century, to show what advanced ideas were prevalent at that remote period with regard to art. Even the modern catchwords of "correct taste and high æsthetic principles" are found in this remarkable novel. A few of the leading facts in the history of Japanese art were then noted, particularly as regards the life of the Hogarth of the country, the renowned Hokusai. By the kindness of Mr. W. H. Patterson, his famous work, "The 100 views of the mountain Fusiyama," were exhibited, to show his skill. After a full explanation of the general principles on which their art is founded, and a description of the way a Japanese artist works, a quotation was given from Mr. W. Anderson, illustrating the distinction between the ordinary artisan and the inventor artist, who, gifted with talents of a very high order, designed and carried to completion the splendid works in bronze, porcelain, and lacquer which have reached Europe. Some amusing instances of the marvellous skill said to have been attained by the old masters were cited, such as that of the artist who drew a dragon, and, as he completed the eye of the monster, it rose and flew away. The famous horse painted on a temple screen was also mentioned, which was nightly accustomed to leave the picture and roam the rice fields, but was at last recognized, and its ravages stopped by blotting out the eyes of the masterpiece. The different substances employed in their art industries were indicated, and the concluding portion of the lecture was devoted to describing the more important, such as lacquer, ceramics, metalwork, and enamels. A concise history of the methods employed in lacquer was given, and examples of this beautiful art shown, more particularly on sword mountings. A fine example in the possession of the reader was exhibited, with eight distinct varieties of lacquer used on it, beside many other processes of inlaying and other arts peculiar to Japan. The remarks made on the various kinds of pottery and porcelain were illustrated by specimens of each manufacture. The stone wares of Bizen, Raku, and Soma were discussed, and the porcelain of Kaga and Kioto ; whilst the famous Satsuma and its imitations were fully explained. The subject of metal work occupied some time, as,

by the kindness of Mr. Henry Matier, J.P., a very choice collection of the finest old bronze and inlaid work was exhibited and described. Much satisfaction was expressed among the audience that the late disastrous fire at Dunlambert had not materially injured any of these masterpieces. The subject of bronze casting was entered into, and a brief account given of the Japanese process of founding, which is similar to that known in Europe as "cire perdu." The different subjects commonly chosen for delineation by their craftsmen were mentioned at length. The religions and mythology of the country were briefly touched on, the seven favourite divinities and the five monstrous animals frequently found on their art productions being remarked on, and examples of some of them pointed out as fashioned in bronze, pottery and enamels. The subject of enamels was taken up in the last place. The superiority of Japanese work was indicated by the comparison of some examples of the middle period, in the form of plaques and vases, with old Chinese work. The lecturer then concluded by giving a short description of some of the beautiful works in bronze and other metals kindly lent for exhibition on the occasion by Mr. Henry Matier, J.P. A large flower vase from a Japanese temple, cast in bronze, and properly inlaid with silver, having panels on each face in raised metals, one representing a god seated beside the national vehicle, the jinrishka, was much admired. Another was particularly noticeable for the skill with which a dragon, encircled by clouds, was depicted. A large plaque, with a monstrous cuttle-fish seizing an unfortunate wretch, who has endeavoured to pilfer a vase lying on the sea beach, was much remarked for the masterly skill displayed in its manipulation and the precious metals used. Specimens of the best work, in wrought iron, inlaid with gold, and chased in high relief, were also shown. The incense burners, of elaborate bronze work, are unique of their kind.

6th January, 1885.

PROFESSOR EVERETT in the Chair.

JAMES MUSGRAVE, ESQ., gave an account of

A RECENT VISIT TO AMERICA,

Including the Yellowstone Park and the Colorado, illustrated by Photographs.

MR. MUSGRAVE said, on the 7th August last he left Liverpool with one of his brothers, for New York, in the Germanic, one of the finest of that White Star line of steamers of which the people of Belfast had reason to feel proud. His object in proceeding to America was two-fold; first, to attend the meeting of the British Association at Montreal, which would give him an opportunity of gaining some knowledge of the Dominion of Canada; and, second, to visit, amongst other places, the scenery which the writings of Washington Irving and Fenimore Cooper had invested with the true spirit of romance, and to observe for himself, even superficially, the people and the institutions of that wonderful country.

Mr. Musgrave then described a visit to the Yellowstone Park, which a few years ago was set apart by Act of Congress as a national park for the American people. Mr. Rigg, president of the London Association of Engineers, had joined in the trip. A circular tour was arranged with the Northern Pacific, the Union Pacific, the Chicago and Alton, and the Baltimore and Ohio Railways, a tour which, with an extension into the Denver and Rio line, he could recommend to any one desirous of seeing that country. He wished to thank Mr. Mackenzie, of the Baltimore and Ohio in Philadelphia, and Mr. Macdougal,

of the Northern Pacific in Montreal, for their attention and forethought, which enabled the party to accomplish the journey without a single hitch. After giving some account of the journey through the older parts of the United States, he said that at Rock Island they crossed the Mississippi, which, even at that distance from New Orleans, is a broad navigable river. There they saw the Government arsenal and armoury, which, as well as many private factories, are worked by water-power, derived from a great dam at Molines. St. Paul, the capital of Minnesota, is one of the most thriving towns in America, containing 100,000 inhabitants. Minneapolis, another town of almost equal importance, is only eight miles distant, and, though some jealousy exists, they are no doubt fated to become one town. St. Anthony's Fall is the overflow from what was said to be the greatest waterflow in America. It drives a large number of flour mills, one of which they examined carefully. It was said to turn out more flour than any other place in the world, and that they could well believe. What surprised them most was that the country appeared richer than that to the east of Chicago. There were rich corn crops on either side of the railway, interspersed with small towns devoted to various manufactures. He was shown a factory where one thousand ploughs were turned out every day.

From St. Paul they entered upon the vast tract of prairie land now so actively developing by the Northern Pacific Railway, through their commissioner, Mr. Lamborn, of St. Paul, who gave him the maps now on the table. Travelling day and night through the territories of Minnesota, Dakota, and Montana, they stopped at Amnabar, the nearest station to Yellowstone Park, which lies principally in the territory of Wyoming. The prairie was not so flat as he expected ; every here and there are hillocks, with occasional groups of small trees. The Missouri River is navigable for steamers up to the town of Bismarck, and there is a fine suspension bridge across the Missouri, connecting Bismarck with Mandan. At Dickenson they parted with a fellow-traveller, who was president of several large cattle ranches, and the groups of head ranchemen and

cow boys who were waiting to receive him gave them a very favourable idea of the class of men engaged in developing that country. He produced a newspaper called the *Bad Lands Cow Boy*, which gave some idea of the state of society in that region. A special Pullman car was provided for members of the British Association at St. Paul. Sir Richard Temple and some of his friends from the Winnipeg excursion joined them at Targo, and the novelty and excitement of conveying so large a company in four-horse "stages" from the railway terminus over the rough roads and through the wild scenery leading to the Mammoth Springs Hotel was a fitting preparation for the extraordinary country they were about to see. They had been told that that hotel cost £40,000. Everything was on a large scale, and the electric light was used. It was crowded with the most picturesque assembly of men he had ever seen. Members of the British Association bargaining for carriages to convey them for a week through the park; stage coach owners and drivers, ranchemen, cowboys, trappers; most of them in distinctive and picturesque dress, formed a scene he enjoyed greatly. At dinner they noticed a party of six dining together. His brother fell into conversation afterwards with one of them, who, when he knew that they were Britishers, stepped out in front of them and exclaimed, "You are English; I love the English; I am an Englishman myself;" and then he described how he had been taken prisoner while serving in the army of Maximilian in Mexico, and obtained no relief from the American Consul, but when he applied to the British Consul he was immediately released, and added, "Is it any wonder I am proud of being an Englishman?" In the morning they visited the Mammoth Springs, which the lecturer then described, and exhibited photographs of them. In the course of their visit to the boiling springs, they met a noted photographer, Mr. Watkins, of California, who was so particular as to his atmospheric effects that he kept his camera ready in front of "Old Faithful" (the name of one of the springs) for two days, waiting for a clear sky, as clouds would have marred the picture. Having stopped at "Marshall's," where they met travellers of various nationali-

ties, they made an early start for a long day's drive through the forest to the Grand Canon of the Yellowstone. The forest consisted mainly of young trees. In some parts there were miles of space covered with the black stems of trees, the result of forest fires, while the surface underneath was covered with young trees a foot or two high. Their coachman was invaluable in these long drives, of a class one rarely meets with at home. He was familiar with English literature, and full of curiosity as to England and the mode of life there. He had a capital tenor voice, and they asked him to sing the American National Anthem. He struck up the air of "God Save the Queen" to words which were new to them, and which, he thought, were little known in this country. He would give them the first verse :—

> "My country, 'tis of thee,
> Sweet land of liberty,
> Of thee I sing.
> Land where my fathers died—
> Land of the pilgrims' pride—
> From every mountain side
> Let freedom ring."

They all joined in a hearty chorus, recognising in such an apostrophe to liberty wedded to our own national air, another tie of sympathy between the American people and the mother country, which has been the parent of liberty in its best and broadest sense. Although very tired when they reached the tents near the Grand Canon, they started off to the Falls. The Yellowstone was a considerable river, and the height of the lower fall is 350 ft., more than double that of Niagara. The Grand Canon, of which many people spoke with the greatest rapture, surpassed anything he had seen of rugged scenery. A canon is a water course of immense depth. In Colorado and Wyoming there is so little rain that the river banks are not, as in this country, worn to an easy slope, but are so precipitous that they cannot be climbed. In Yellowstone Canon they could not get even half way down to the river, but, standing on a projecting point, they saw the river below, with steep cliffs rising to a height of some 1,200 feet on either side. The rocks

were worn into pinnacles of the most fantastic forms, the prevailing tone a rich yellow, but stained in parts with colours so brilliant that they saw Mr. Thomas (an accomplished artist whose pictures he hoped to see at the Academy), who joined their party, use carmine and other vivid colours to produce his effects.

They next journeyed to Helena, Salt Lake City, the Rocky Mountains, the Colorado Springs, and back to New York by way of Kansas City, St. Louis, and Baltimore. Such were some of the physical characters of the portion of the American continent through which they travelled. He would conclude with a few words regarding the people. Owing to the unfortunate tendency of able writers to make amusing books of travel, the American people had been too often presented to them in a grotesque attitude. He expected to see them boastful, talking through their noses, and speaking a language which was a travestie of the English tongue. He found them free from "brag;" the men particularly expressed themselves on all subjects with moderation, and had much repose of manner, while their provincialisms were not more numerous than in England. He was glad to observe everywhere a tone of sympathy for the "Old Country," and a desire to have the good opinion of the "Britisher." The American people are thoroughly imbued with the spirit of the best English literature. Their principal class-books are English. Sir Henry Roscoe found his "Chemistry," and their companion, Mr. Rigg, found his history of the steam engine, in daily use in the Boston colleges. In the gallery at Washington devoted to mementos of those who worked for the independence of the United States, the portrait of Lord Chatham is placed by the side of Lafayette, and the speeches of the former, and of many other great English speakers, give the keynote of the best American oratory. A St. Louis gentleman told him that Thackeray's portrait of Colonel Newcome was his ideal of what a man should be. He was not long in America till he almost forgot he had crossed the Atlantic, and he came back from Canada and the United States impressed with the hope that we may never do any-

thing to forfeit our position as the friends and natural leaders of the English-speaking race throughout the world.

The lecture was illustrated by large photographs of scenery, by geological specimens, and by diagrams, which were explained by the lecturer.

3rd February, 1885.

Robert Young, Esq., C.E., in the Chair.

Thomas Workman, Esq., read a Paper on

EASTERN REMINISCENCES, WITH LANTERN AND PHOTOGRAPHIC ILLUSTRATIONS.

3rd March, 1885.

R. Lloyd Patterson, Esq., J.P., in the Chair.

J. H. Greenhill, Esq., read a Paper on

ELECTRIC LIGHT AND TRANSMISSION OF POWER BY ELECTRICITY.

And Repeated (by request of the Council) on 5th March, when Dr. Everett, F.R.S., *presided.*

Frictional Electricity is always of high tension, but of small quantity. Thermo-Electricity has, up to the present, been of comparatively low tension, but of large quantity, whereas Voltaic and Magnetic Electricity may combine within certain limits both tension and quantity.

Metals in their relation as conductors of electricity may be compared to pipes for the conveyance of water, but with this notable difference, that whereas pipes of a given diameter or bore, whether made of lead, iron, copper, or fire-clay, will convey an equal quantity of water at a given pressure, metallic conductors of electricity vary enormously in this respect. For instance, a pure copper wire will conduct about seven times as much electricity of a given tension or pressure as an iron wire of the same size ; hence if iron cables were used instead of copper, they would require to be of much larger size where much current would be passed along, as in the case of central district lighting. No economy in the first cost would therefore arise, and it is this difficulty which operates so strongly in preventing stations for the supply of electricity being established.

Any fatal accidents which have occurred have invariably arisen with high tension currents, but it is noteworthy that currents of a certain tension may be practically harmless if continuous or unbroken, whereas the same "pressure" may produce most serious results if intermittent or alternating; in other words, if there are periods of cessation in the flow of the current, or if it is made to pass in one direction and then in the opposite. The Board of Trade stipulated, in the Act of Parliament passed for permitting companies to supply electricity from central stations for domestic use, that the tension for *direct* currents inside the house should not exceed 300 volts (the volt is a term applied to the unit of tension), whereas, with alternating currents, the limit should not exceed 100 volts. One advantage gained in the use of high pressure is that the sectional area of the copper wires for conducting the electricity may be much less than what would be necessary for low tension, thus reducing the first cost of the installation; and, up to certain limits, there is greater economy in the working; but on the other hand there are certain objections to very high tension (besides the danger), as the light produced when arc lights are employed is of an unpleasant blue or violet colour.

Frictional Electricity, because of its high tension, has not been used to any great extent, except for experimental purposes, or for the explosion of mines; but latterly a new field has been opened for its employmeut by a little apparatus for lighting gas.

It is noteworthy that although the so-called "storage" of electricity has created a great deal of interest of late, yet as a matter of fact the "bottling up" has been known for centuries in respect to Leyden jars, whereas the "storage" of the present day is not a material accumulation of the current, but merely changing the chemical condition of lead plates and the acid in which they are immersed, by the action of a current of electricity when passed through them, and it is the tendency for the lead plates and acid to return to their original condition, which again gives rise to new electrical currents when a connection is made to permit the currents to flow. The action which takes

place in the lead plates and acid in the act of charging and discharging, is as follows, according to Dr. Frankland (see the report published in "The Electrician" of 31st March, 1883): "Occluded gases play no part, practically. The active material on lead plates is lead sulphate. The initial action in charging the battery is the electrolysis of sulphuric acid into hydrogen, sulphuric anhydride, and oxygen. The hydrogen decomposes the lead sulphate on the negative plate into spongy lead and sulphuric acid, whilst the oxygen decomposes the lead sulphate on the positive plate into lead peroxide and sulphuric anhydride. All sulphuric anhydride is at once converted into sulphuric acid. In discharging, the initial action is again the electrolysis of sulphuric acid, which restores the coating of the two plates to the original condition of lead sulphate. As the charging of a cell is attended with the liberation of sulphuric acid, and its discharge with the abstraction of this acid from the liquid contents of the cell, it is only necessary to ascertain the specific gravity and consequent strength of the acid, to determine the amount of charge in a cell at any given moment, provided that the specific gravity of the acid in the *charged* and *uncharged* conditions of the cell be previously known. In the case of a cell with which Frankland experimented, each increase of 0·005 in the specific gravity of the dilute acid, meant a 'storage' of available energy equal to 20 amperes for one hour."

"Thermo-electricity," by reason of its low tension, has only been used for electro plating, as in this process high tension is not admissible. "Voltaic electricity" has been employed to a limited extent for electric lighting; but one serious drawback to its general adoption for this purpose is the great expense entailed, as electricity produced by the consumption of zinc and acid in a battery costs, in round numbers, about ten times more than the same amount of electricity obtained by the use of a dynamo machine.

Soft iron, after being magnetised, loses nearly all its magnetism as soon as the exciting agent is removed; but it retains a very minute trace, although perhaps not sufficient to indicate its presence to a marked degree, and it is this residual trace which plays so important a part in dynamo machines.

All magnets have innumerable "lines of force," as they are technically called, in their vicinity; and unmistakable evidence of their existence is obtained when iron filings are brought within their influence. The filings cluster more densely near the ends of the magnet than at the centre, and they appear to arrange themselves in arcs of curves from one extremity to the other. In Fig. No. 3 on the screen, a novel arrangement of apparatus is shown, consisting of a magnet held between two sheets of glass. There is a third sheet of glass fastened at a little distance from the others, thus allowing a space in which iron filings can be scattered ; thus the process in which they arrange themselves in the direction of the lines of force can be observed.

Soft iron or steel may not only be magnetised by proximity to another magnet, but it may also be acted upon to a far greater extent by wrapping insulated wire upon it, and sending a current along the wire. If the current is again passed along the wire in the opposite direction, the end which was formerly a North Pole is now a South. Faraday made the discovery that if a coil of wire with its ends connected together was moved in a certain manner near to a magnet, a powerful current was generated in the wire. Of course if the ends of the wire were not joined, no current was developed, as in all cases where a current passes along a wire, the circuit must be completed, either by direct connection of the ends, or by the interposition of some conducting medium, such as the earth or liquids, more especially if the latter are acidulated. Even in the case of "arc" electric lighting, although it may at first sight appear as if the circuit was broken between the carbons, as indicated by Fig. 4 on the screen, yet the continuity of the conducting medium is maintained by the intensely heated air at the point of separation, and by the particles of carbon which jump across the space. As the polarity of the magnet can be changed by reversing the direction in which the exciting current flows, so can the direction of the current in the coil be altered by changing the position of the poles of the magnet. In Fig. 5, the coil is supposed to move from left to right, or from the North pole

of the magnet to the South. The current flows in the ring downward in the side nearest to us. When the ring approaches the centre of the magnet, the current gradually gets weaker, by reason of the fewer number of "lines of force" being embraced within it. The current begins to circulate in the ring in the opposite direction, after the centre of the magnet has been passed. The intensity at which the current flows in the ring is due to two things, namely the speed at which the movement is made along the magnet, and the "strength" of the magnet itself. A similar result occurs if the ring is made to move in the arc of a circle between the poles of a horse-shoe magnet, as shown in Fig. 6. In the next diagram (Fig. 7), the horizontal lines between the poles of a horse-shoe magnet are supposed to represent the "lines of force"; it will be observed that when the ring is perpendicular to these lines, it encircles the largest number; but when angled, the number decreases, thus producing a fall in the potential of the current.

It is possible to obtain all the effects of a magnet, although no iron or steel may be present. If, for instance, a wire is coiled into a ring or helix, and a current is caused to traverse it, the air space in the centre becomes filled with magnetic lines of force. Some electrical machines are constructed in this manner, so that lightness of the moving parts and ventilation may be obtained, besides avoiding what are termed Foucault or wasteful currents, which sometimes arise if iron is employed without due precaution having been taken in the construction. In the earlier machines, these wasteful currents in the iron itself proved highly objectionable, causing much power to be absorbed uselessly; but in good machines of the present day, iron is employed with great advantage, and without any wasteful currents being generated to signify.

Machines may be divided into two classes—*direct current* and *alternating*—and these may be subdivided into magneto and dynamo generators. In *direct current* machines, the electricity always flows along the conductor in one direction, but with *alternating* dynamos, the current flows in one direction, and then in the reverse, but the changes in direction amount to an immense number per minute, up to ten or twenty thousand.

In magneto machines, the magnets are permanent steel ones, but in dynamos the magnets are of iron, with coils of wire wrapped upon them, and the magnetism is produced by currents of electricity passing along the wire : such currents may either be produced by the machine itself, or by a separate "exciting" machine or battery. Again, in direct current dynamo machines in which the magnets are excited by their own currents, the magnets may be coiled with comparatively thick wire, and made to receive all the current generated, which, after passing along the coils surrounding the magnets, proceeds to the lamps or external circuit, thence back to the machine. These are termed "series" machines. Instead of the magnets having a comparatively short length of thick wire, thus producing but few turns, they may have an immense length of fine wire coiled upon them, and returning direct to the revolving armature (which is the name applied to the rotating coils of wire in which the currents are generated), with a separate set of conductors leading to the lamps; thus only a very small proportion of the current generated in the armature passes round the magnets, in consequence of the fineness of the wire and its extreme length. These are termed "shunt wound" machines. It is noteworthy that the small amount of current which passes round the magnets in a "shunt" machine is quite as effective as the large or total amount of current which flows round the magnets of a "series" machine, in consequence of the greater number of turns in the case of a "shunt" arrangement, as one ampere (the unit applied to *quantity*) passing along one hundred turns of wire on a magnet is as effective, practically, as one hundred amperes passing *once* round the iron. Frequently machines have their magnets coiled both with a fine "shunt" wire and a thick "series" one, and the current passes along both, but in inverse ratios to the relative resistances. They are thence termed "compound," and are generally employed for incandescent lighting, as they are more nearly self-regulating, provided a regular speed is maintained, whereas with "shunt" machines it may happen that if a great number of lamps are switched off, too much current passes through the remainder, thus injuring

or utterly destroying them. The action of a dynamo machine is as follows:—When the armature is caused to rotate, the residual magnetism in the iron induces a feeble current in the revolving coils ; this current passes along the wire encircling the magnets, and strengthens the magnetism, which in turn induces a stronger current. Thus an action and reaction takes place, but with such amazing rapidity that practically the machine is enabled to generate its maximum strength of current instantaneously.

I have referred to both the "arc" and "incandescent" forms of electric light. The former is that produced by the separation of two carbons after the current has been established ; it meets with great resistance at the point of separation, and thereby heats up the ends of the carbon to an enormous temperature, thus producing a light of intense brilliancy. Both carbons consume away, but not at the same rate. The one at which the current enters from the machine, and called the "positive" carbon, is consumed twice as fast as its neighbour or "negative" carbon. The "positive" has a concave or hollow-shaped end, whereas the negative is pointed. A portion of the positive is carried to the negative by the action of the current. This is only the case when direct currents are used, but with alternating currents both carbons consume alike.

With "incandescent" lighting, the lamp consists of a small glass globe, from which all the oxygen has been exhausted. Inside the globe there is a fine filament of a carbonised material, made by different inventors from various products, but in the final condition reduced to carbon. The current traverses this filament, which being of considerable resistance, becomes heated to whiteness, and thus gives off a beautifully clear and soft light With reference to the power required to drive an electric machine employed for generating currents of electricity for "arc" or for "incandescent" lighting, the same power will produce about ten times the aggregate light with an "arc" compared to "incandescent," hence it is more economical where large spaces have to be illuminated ; but for confined spaces, especially where there is not much head room, the arc light is far too brilliant. Under these conditions, the loss of power can

be submitted to in the employment of the "incandescent" light. As a rule, one actual horse-power will give from 1,500 to 1,800 candle power by arc lighting, or from 160 to 180 candles by incandescent lamps. Another system of lamp, somewhat between the arc and the incandescent, is what has been termed "semi-incandescent." It consists of a thin rod of carbon which is caused to press against a heavy block of the same or other material, and the light is emitted where the two unite; but this method has not been much employed.

The method in which an installation of *arc* lighting is carried out is quite different from that which has to be adopted for *incandescent*. In the former, the lamps are arranged in "series," that is, the current is driven through the first lamp, then through the second, and so on, finally returning to the machine. The *quantity* of electricity required is always the same whether one or forty lamps are used, but the *potential* or *pressure* of the current has to be increased for every lamp. With incandescent lighting, a portion of the current is sent through each lamp independently of its neighbour. The cables are arranged in parallels, very similar to the sides of a step-ladder, and the incandescent lamps are attached between them, thus being analogous to the steps of the ladder. It is obvious by this arrangement that the *pressure* or *potential* of the current should remain constant, but the *quantity* should be in proportion to the number of lamps, ten lamps requiring ten times as much current as one lamp.

Now, as regards the danger of fire in connection with electric lighting, there is no artificial mode of illumination so *safe* if properly installed, and none so *dangerous* if erected in ignorance of what is necessary. The danger arises from what I may term the insidious nature of the current. If there is a leak in a gas pipe, it can generally be detected without the reprehensible method of trying for it with a light, but there may be a condition of affairs with an improperly erected installation of the electric light which will give no warning before damage is done. For instance, cables may be dangerously near to iron without being properly protected; in course of time they may come into metallic

contact with the iron, and serious results may happen. Now it is possible so to arrange matters that even if all the cables or wires in the building were adjacent to metallic materials, no serious harm could happen ; and the method is to insert in various parts of the building *safety fusible connections*, so that if any accidental "short-circuiting" should occur, the safety fuse would instantly melt, and thus stop all further progress of the current. Another ingenious method is by using patent safety cut outs, which consist of a magnet and counter weight or spring. The latter overpowers the magnet's influence under ordinary circumstances, but if the current, from any cause, increases beyond its normal strength, the power of the magnet is increased, and overcomes the weight or spring, and thus stops the current altogether. Again, the cables and wires may all be well protected from any external metallic fittings, and yet there may be danger of the wires getting very hot by reason of them being far too small in sectional area for the current they have to carry. The fusible connections are equally effective in this event.

As to the advantages of using the electric light for mills, factories, business premises, and private houses, there are numerous cases where electricity is infinitely superior and very much cheaper than gas ; and on the other hand, there are many places where gas is cheaper, and good enough as an illuminant. Wherever power is available, either by water or steam, then the electric light is by far the best, especially if the hours of lighting are sufficient to permit only a small per-centage of interest on first cost to fall upon each hour's lighting. Flour mills, which generally work all night, are well adapted for the electric light, whereas large factories, whose ceilings are so low that arc lights are not suitable, and where light is required for only a few hours daily, even in the winter months, do not offer such a good opportunity to make the incandescent electric light pay. Again, in shops, the cost of gas may possibly be somewhat less than the electric light, especially if power has to be specially provided, but the gain annually in the preservation of the fragile goods by the use of the electric light compared to the destruction

caused by gas, (not to speak of the unhealthiness by the latter to the employés), is so enormous, that many firms who have adopted electricity, in London and elsewhere, have increased the original installations four-fold. With respect to the employment of incandescent lamps in houses, I have had personal experience of the benefit arising by the use of electricity over other artificial modes of lighting, as I have had the electric light in my house for several months, with most satisfactory results. A careful perusal of the following table will no doubt prove instructive. It was read by Mr. Crompton at the Health Exhibition in London; the results were the work of Dr. Meymott Tidy and others :—

Burned to give light of 12 candles, equal to 120 grains per hour.	Cubic feet of Oxygen consumed.	Cubic feet of air consumed.	Cubic feet of Carbonic Acid produced	Cubic feet of air vitated.	Heat produced in lbs. of water raised 10° Farht.
Cannel Gas ...	3·30	16·50	2·01	217·50	195·00
Common Gas ...	5·45	17·25	3·21	348·25	278 60
Sperm Oil ...	4·75	23·75	3·33	356·75	233·50
Benzole ...	4·46	22·30	3·54	376·30	232·60
Paraffin ...	6·81	34·05	4·50	484·05	361·90
Camphine ...	6·65	33·25	4·77	510·25	325 10
Sperm Candles ...	7·57	37·85	5·77	614·85	351·70
Wax Candles ...	8·41	42·05	5·90	632·25	383·10
Stearic Candles ...	8·82	44·10	6·25	669·10	374·70
Tallow Candles ...	12·00	60·00	8·73	933·00	505·40
Incandescent Electric Light	none	none	none	none	·13·80

It will be seen by the above that bad as gas may be, it is not nearly so injurious as oil and candles, but the electric light is far superior to them all.

With reference to the use of electricity as a transmitter of power, the machinery employed is a double set of dynamos, practically the same as used in electric lighting. By driving one machine, the current is generated, and by allowing this current to pass through another machine, its armature revolves,

and either propels a car, or turns other machinery. When electricity is employed for the propulsion of tramcars, the current may be conveyed along an insulated rail or cable, and collected by the running vehicle by means of a brush of copper wires made to press on the conducting rail. As a rule, only from 50 to 60 per cent of the original power can be utilized when transmitted by electricity, but even this small percentage may be most valuable in certain cases, especially if the original power is obtained from a waterfall which would otherwise go to waste, such, for instance, as the electric tramway at Portrush.

Another method for making use of electricity for motive power is by using accumulators or storage batteries. The objection to these at present is their weight and size, but I believe there is a great future for the employment of storage batteries, and it would not surprise me to find the tramcars of Belfast and other towns propelled by electricity before many years pass by. Storage batteries are of immense service where temporary stoppages of the machinery occur, or for the regulation of the light when the power is of a fluctuating nature; also, where a few lights are required to be kept in operation all night.

The lecture was illustrated by numerous photographs thrown on a screen by dissolving lanterns, operated by Mr. R. W. Welch. Not only were there diagrams for shewing the special parts of the machines, but the various types of the leading dynamos of different construction were illustrated. The experiments, named by Mr. Greenhill in the early part of the paper, were most successfully carried out.

At the conclusion, on the second evening, Prof. Everett, F.R.S., in proposing a vote of thanks, said, that he felt great pleasure in presiding that night, and he was very much pleased that the lecture had been repeated, as it gave him and others who were not present on the first evening, an opportunity of hearing it on the second occasion. He had to congratulate Mr. Greenhill for the lucid explanations of what some might think rather complex matters, and for the successful way in which the experiments

had been carried out. He was sure that it must have been a matter of surprise to many to witness the very steep gradient which the small electric car had been able to ascend, and he also wished to direct the attention of the audience to the extremely small dimensions of the dynamo which Mr. Greenhill had constructed for his experiments, but which proved so remarkably powerful.

24th March, 1885.

Joseph J. Murphy, Esq., in the Chair.

J. Brown, Esq., read a Paper on

FORMATION OF A STALACTITE BY VAPOUR.

The reader described a curious phenomenon which he had observed during the electrolysis of the double chloride of aluminium and sodium fused in a small porcelain crucible provided with a porous partition. The anode was of carbon, and the cathode platinum-foil.

A considerable quantity of vapour was given off, especially from about the anode, forming a white smoke and depositing a white substance, doubtless mainly hydrated aluminium chloride, on the carbon rod, and about the mouth of the crucible, ultimately closing up the latter all but a small hole, through which the vapour poured rapidly. From this hole there grew out a beautifully delicate little tube about $1\frac{1}{2}$ inch long, and tapering from about $\frac{1}{6}$ inch at the base to $\frac{1}{10}$ inch in the middle of its length, after which it increased in diameter, and also flattened out owing to the vapour-jet coming close over the bend of the platinum-foil cathode, which seemed to cause, by some kind of eddy current, a flattening of the stream of vapour.

Soon afterwards the supply of vapour slackened, and there was a corresponding diminution in the size of the tube in the last quarter-inch of its length till the end became almost closed. The formation of this tube seems quite analogous to that of the ordinary tubular lime-carbonate stalactite deposited from dropping water by contact with the atmosphere; only we have here a tubular deposit of hydrated aluminium chloride by the combination, at the edge of the growing tube, of the water-vapour in the air with the anhydrous chloride contained in the vapour-stream.

24th March, 1885.

JOSEPH J. MURPHY, ESQ., in the Chair

WILLIAM WORKMAN, ESQ., read a Paper on

VENTILATION AND HEATING OF CHURCHES AND DRYING ROOMS.

HEATING and ventilation are mostly in inverse ratio to one another. If ventilation be good, heat is little, and draughts great, coughs, both loud and deep, vie with the speaker for the attention he should have, and never fail to get more than an intelligent audience should give to inarticulate sound. If heat be good, carbon acid rapidly accumulates, and heads nod more familiarly than reverently towards him who desires their lively attention. The problem to be solved may be thus stated :—How to obtain air without coughs, and heat without headaches ;—or, ventilation without draughts, and warmth without running it to waste through ventilators.

I suppose a church or assembly-room to be air-tight as buildings go, that there be no ventilating openings except where indicated, and that the seams of the ceiling, if sheeted with wood, be fairly close and tight. At one end the heating apparatus is placed. There is no reason why it should not be inside the building instead of attached, should circumstances make that arrangement desirable. To the heating chamber a flue leads to supply fresh air. Opening below the level of the apparatus from it ascends another close to the level of the ceiling, where it dis-

charges freely the hot air into the building. The outlets for the cold air are through the floor, numerous and moderate in size, opening into a flue below the floor, and carried to an upright flue, ending at or above the top of the building like a chimney. The expected result from this arrangement, tracing the air from its inlet, is—the air being admitted below the level of the heating apparatus—none of the heated air is likely to escape from a blow-down ;—also, having a flue full of heated air of considerable height, force is added to the current in proportion to the height. When discharging into the church according to the law of lighter fluids, it will float on the colder air, forming a sheet of warm air close under the ceiling. This will constantly be supplied and displaced downwards by the continuous flow of hot air from the flue, until ultimately all the original cold air is displaced by the warm air. While this is going on above, the coldest air is continuously being driven down through the openings in the floor, carried through the horizontal flue to the upright one, where, still having some ascending power from the remains of its heat derived from the apparatus and that added to it by the assembly, it will assist in keeping up the circulation. The draught towards an outlet for air is of a very different nature to that from an inlet, being more diffused and tending to flow in radii towards the centre, namely, the outlet. Those from an inlet may pass for a considerable distance in an unbroken stream, and, if passing in with much velocity, may stir up a wide area of draught by its friction. This may be observed on a stormy night by opening a window half-an-inch wide when the wind is blowing against it: this will stir the whole air of a moderate sized room so that a draught may be felt in almost any part of it. The two flues, when no heat is being used, would still act to some extent as ventilators. In the case of a room full of people, if there were only a very slight current at first, it would soon increase by the heated air from the assembly passing up the outlet flue, the pure cool air being, as it were, pulled in up the inlet flue. The air in the building should be as much as possible under the same conditions as in that a diving-bell, where the only escape is at the

bottom. The same plan, it would seem to me, would be the most economical method of applying heat in drying rooms for yarn, &c., as none but the coolest air could escape, and the amount of hot air admitted could be regulated, so that no air would leave the apartment until completely saturated with vapour. By the ordinary method in use, for heating both drying rooms and churches, the hottest air immediately makes its way to the highest part of the building, and escapes by the nearest outlet before it has done much of its intended work. A method which has been successfully tried in our iron war ships, but not yet in our churches—that is, to coat the interior with a non-conducting paint—would be worth the experiment; it would likely prove a means of saving fuel and adding considerably to comfort. Every one knows how much more comfortable a new house seems, and no doubt is, after it has been papered and painted, and how one will almost be inclined to shiver on going into a new house with its bare plastered walls. It is not a mere imagination that drawing the curtain close adds to the comfort of a sitting-room on a cold winter night. The curtains are really like blankets, only more distant from the body than would be comfortable in bed. Let anyone try sleeping in a room with the blind up in the cold weather instead of drawn down. The difference in temperature will be quite perceptible without the help of a thermometer, a difference hardly to be expected from a thin piece of cotton hanging in front of the window, or the loosely-fitting slips of a Venetian blind. We have all noticed the dew forming on the carafe of cold water on a dining-table. Often it will trickle down in streams. Did anyone ever notice the table-cloth or napkin in that state, or even damp, from the same cause? In former days tapestry must have added materially to the comfort of rooms, acting as a non-conductor between the cold walls of the building and the bodies of its inmates.

April 14th, 1885.

W. H. Patterson, Esq., in the Chair.

The Rev. Robert Workman, B.D., read a Paper on

LAND TENURE AND CULTURE IN ANCIENT IRELAND.

The Rev. Mr. Workman in the first half of his paper endeavoured to show that all the peoples of Christendom originally held the land in common, and that the institution now known as "the village community" prevailed amongst them. This, he said, was originally the condition of Ireland. In Ireland every "community" became a clan, and the chief soon gained a position of great power. In the primitive period, the members of the clan were comparatively independent of the chief, who was merely their headman or leader ; but by the sixteenth century the chief had become chief lord and absolute owner of the land, which he rack-rented. Having referred to the circumstances which brought about this change, Mr. Workman made a lengthened and interesting reference to some curious customs pertaining to agriculture that existed among the ancient Irish. It was perfectly evident, he said, that only a small part of Ireland was cultivated during the 16th century. If they were to credit the high authority of Sir W. Petty, the population at that period could not have been very much above a million. Such a population did not require a large area of tilled land, and no works of supererogation were performed by them. From an early period, moreover, Ireland was a country of forests. In

1542, "the English troops, penetrating to the centre of Ulster, found it a jungle. Tyrone County is described as not containing one single castle, nor yet one town walled, but full of wood, great bogs, and waters, here called loughs." The English, whose appetites were proverbially good, could hardly understand how the Irish got a living in so desolate a land. In 1560, Lord Fitzwilliam, Governor of Dublin, in great fear about rebellion, wrote—" The country is for the most part a wilderness, but the desolation is no security ; the Irish would keep the field when the English would starve. No men of war ever lived the like, or others of God's making, touching feeding and living." In ancient times the good cheer of Tara consisted in devouring great quantities of meat, for neither bread nor drink were mentioned. Nor did bread appear to have been the staff of life to the Irish people of the 16th century. Export of hides was the mark of a pastoral flesh-eating people ; and about the middle of the 16th century " the Irish sent great quantities of raw and tanned hides and sheepskins and some furs to Antwerp, also some coarse linen and woollen cloths." Fish were exchanged with France and Spain for wares by chieftains on the coast. They must suppose that after the Plantation, Ulster rapidly prospered in agriculture, and became largely a grain-producing country ; but the records of the exportation from Belfast in 1663 showed by their preponderance of flesh, tallow, and skins that the greater part of the land was untilled. Having further referred to the character of the exports at later periods, with a view of indicating the condition of the land as regards cultivation and the pursuits of the people, Mr. Workman, in conclusion, said the subject affords fresh illustration of the persistent tenacity of the characteristics that distinguish the different races of mankind. We are assured that the negro race is as old as the Egyptian monuments, and we know that the Jews have continued to be the world's greatest merchants for more than 2,000 years. So here in Ireland we may regard the eagerness with which our peasantry cling to the soil as a survival of the spirit of the ancient village community, the absolute owner of its own land. Moreover, the pastoral instinct has prevailed over

the agricultural amidst all the changes of Irish history. At the present day, Ireland is specially a grazing country, and the Irishman has a proverbial liking for cattle, and pigs, and horses, and must be regarded as one of the least successful agriculturists of the Old World, whilst we are told that it is the Scotchman or the Englishman, rather than the Irishman, who becomes the great cultivator of the boundless grain-growing prairies of the New World.

BELFAST
Natural History and Philosophical Society.

Officers and Council of Management for 1885-6.

President:

WILLIAM H. PATTERSON, M.R.I.A.

Vice-Presidents:

JOHN ANDERSON, Esq., F.G.S.
ROBERT MacADAM, Esq.
Prof. J. D. EVERETT, M.A., F.R.S.
THOMAS WORKMAN, Esq.

Treasurer:

JOHN BROWN, Esq.

Librarian:

THOMAS WORKMAN, Esq.

Secretary:

ROBERT M. YOUNG, B.A.

Council:

PROFESSOR CUNNINGHAM, M.D.
JOHN ANDERSON, Esq., F.G.S.
ROBERT MacADAM, Esq.
PROFESSOR J. D. EVERETT, M.A., F.R.S.
THOMAS WORKMAN, Esq.
JOHN BROWN, Esq.
JAMES WILSON, Esq.
PROFESSOR E. A. LETTS, Ph.D., F.R.S.E.
JOSEPH JOHN MURPHY, Esq., F.G.S.
ROBERT LLOYD PATTERSON, Esq.
WILLIAM H. PATTERSON, Esq., M.R.I.A.
WILLIAM SWANSTON, Esq., F.G.S.
JOSEPH WRIGHT, Esq., F.G.S.
ROBERT YOUNG, Esq., C.E.
ROBERT M. YOUNG, B.A.

SHAREHOLDERS.

[*Denotes holders of three or more Shares.]

Allen, W. J. C., J.P., (Representatives of), Faunoran, Greenisland.
Andrews, Michael (Representatives of), Ardoyne, Belfast.
Andrews, Thomas M.D., F.R.S., &c., Fortwilliam Park, do.
Andrews, Samuel, J.P., Victoria Street, do.
Archer, H., Wellington Place, do.
Anderson, John, J.P., F.G.S., Hillbrook, Holywood.
*Alexander, James, J.P. (Representatives of), Holywood.

*Bateson, Sir Thomas, Bart., M.P., J.P., D.L., Belvoir Park, Belfast.
*Batt, Thomas G. (Representatives of), Belfast.
Bland, Robert Henry, Lisburn.
Bottomley, Henry H., Garfield Street, Belfast.
*Bottomley, William, J.P. do.
Brett, C. H., Chichester Street, do.
Bristow, James R., Northern Bank, do.
Barbour, James, Falls Foundry, do.
Boyd, William, Blackstaff Mill, do.
Boyd, W. S., Donegall Quay, do.
Brown, John Shaw, J.P., Bedford Street, do.
Brown, John, Bedford Street, do.
Brown, William K., Rushmere, do.
Burden, Henry, M.D., Alfred Street, do.
Burnett, John R., Gamble Street, do.

*Campbell, James (Representatives of).
Campbell, John, Lennoxvale, Belfast.
Connor, Charles C., White Linen Hall, do.
Carson, John, Church Lane, do.

*Charley, John (Representatives of), Finaghy, Belfast.
*Clermont, Lord, Ravensdale Park, Newry.
Coates, Victor, Rathmore, Dunmurry.
*Charters, John (Representatives of).
Crawford, William, Calender Street, Belfast.
Cuming, James, M.D., Wellington Place, do.
Calwell, Alexander McD., College Square North, do.
Cunningham, Robert O., M.D., F.L.S., Queen's College, do.
Clarke, Edward H., Elmwood, do.

Darbishire, James M., Lombard Street, do.
*Donegall, Marquis of, K.P., &c. (Representatives of), London.
Drennan, Dr., Chichester Street, Belfast.
*Drummond, Dr. James L. (Representatives of), do.
Duffin, Charles, J.P., Waring Street, do.
Dunville, William, J.P. (Representatives of), Calender St., do.
*Downshire, Marquis of, Hillsborough Castle, Hillsborough.
Dixon, Thomas S., York Street, Belfast.

Emerson, William, Donegall Quay, do.
Everett, J. D., M.A., D.C.L., F.R.S., Queen's College, do.
Ewart William, J.P., M.P., Bedford Street, do.
Ewart, W. Quartus, Bedford Street, do.

*Fenton, Samuel G., J.P. (Representatives of), do.
Ferguson, Henry, M.D., Fisherwick Place, do.
Forsythe, R. H., Holywood.
Finlay, William Laird, Windsor, Belfast.
Finlay, William Laird, jun., Royal Avenue, do.
Fitzgerald, Professor Maurice, Queen's College, do.
Fagan, John, F.R.C.S.I., Glengall Place, do.

Garrett, Thomas (Representatives of), Gamble Street, do.
*Getty, Edmund (Representatives of), do.
Girdwood, H. Mercer, Broughton Maxwell, Manchester.
Gordon, Alexander, M D., Howard, Street, Belfast.
*Grainger, Rev. John, D.D., Broughshane, Ballymena.

Gray, Robt. (Representatives of), College Square North, Belfast.
Gordon, Robert W., J.P., Falls Road, do.
Greer, Thomas, J.P., M.P., Seapark, Carrickfergus.
Gray, William, C.E., M.R.I.A., Mount Charles, Belfast.
Greenhill, John H., New King Street, do.

Hogg, John, Academy Street, do.
*Hamilton, Hill, J.P. (Representatives of), Mount Vernon, do.
*Hancock, John, J.P., Lurgan.
Henderson, Robert (Representatives of), High Street, Belfast.
*Henry, Alexander, Manchester.
*Herdman, John (Representatives of), College Sq. North, Belfast.
Hind, James, Durham Street, do.
Hind, John, J.P., Durham Street, do.
Hind, John, jun., College Street South, do.
Heyn, James, A.M., Ulster Chambers, Waring Street, do.
*Houston, John B., J.P., D.L., Orangefield, do.
Herdman, John, J.P., Carricklee House, Strabane.
Hamilton, Sir James, J.P. (Reps. of), Waring Street, Belfast.
Harland, Sir Edward J., Bart., J.P., Ormiston do.
Hodges, John F., J.P., M.D., F.C.S., Queen's College, do.
Hyndman, Hugh, LL.D., Waring Street, do.
Henderson, James, Donegall Street, do.
Holford, T & A., Cern Abbas, Dorsetshire.

Jackson, Thomas, C.E., Corn Market, Belfast.
Jaffé, John, J P., Donegall Square South, do.
Jaffé, Otto, Donegall Square South, do.
*Johnston, Sir William G., J.P., D.L., College Sq. North, do.
Johnston, Samuel A., Jennymount Mill, do.

Kennedy, James, Falls Road, do.
Keegan, John J., High Street, do.
*Kinghan, Rev. John, Altona, Windsor, do.

Lanyon, Sir Charles, J.P., The Abbey, Whiteabbey.
Lepper, F. R., Ulster Bank, Belfast.
Lakin, Mr. John, Tamworth.

Letts, Professor E. A., Queen's College, Belfast.
Lytle, David B., Victoria Street, do.
Lemon, Archibald D., J.P., Edgecumbe, Strandtown.

*Macrory, A. J. (Representatives of), Ulster Chambers, Belfast.
Mitchell, W. C., J.P., Tomb Street, do.
*Mitchell, George T. (Representatives of), do.
Montgomery, Thomas, J.P., Ballydrain do.
Moore, James, J.P. (Representatives of), Dalchoolin, Craigavad.
*Mulholland, Andrew, J.P., D.L. (Representatives of), Belfast.
*Mulholland, J., J.P., D.L., M.P., Ballywalter Park, Ballywalter.
Mullan, William, J.P., Victoria Street, Belfast.
Murney, Henry, J.P., M.D., Donegall Square East, do.
Musgrave, James, J.P., Ann Street, do.
Murray, Robert (Representatives of), Arthur Street, do.
*Murphy, Joseph John, 2, Osborne Park, do.
*Murphy, Isaac James, Armagh.
Musgrave, Henry, Ann Street, Belfast.
Musgrave, Edgar, Ann Street, do.
Moore, James, Donegall Place, do.
*M'Calmont, Robert, London.
*M'Cammon, Thomas, Dublin.
M'Clure, Sir Thomas, Bart., M.P., V.L., J.P., Belmont, Belfast.
M'Cance, Finlay, J.P., Suffolk, Dunmurry.
*M'Cance, J. W. S. (Representatives of), Suffolk, Dunmurry.
*M'Cracken, Francis (Representatives of), Donegall St., Belfast.
MacAdam, Robert, College Square East, do.
MacIlwaine, Mrs. Jane (Representatives of), do.
MacIlwaine, Rev. Canon, D.D., M.R.I.A. (Representatives of), Mount Charles, Belfast.
*MacLaine, Alex., J.P., Queen's Elms, do.
M'Gee, James, High Street, do.
M'Neill, George Martin, Beechleigh, Windsor, do.

Neill, John R., Holywood.

Patterson, E. Forbes, High Street, Belfast.
Patterson, Mrs. M. E., Ardmore Terrace, Holywood.

Pim, Edward W., High Street, Belfast.
Pim, George C. (Representatives of), Corporation Street, do.
*Pirrie, John M., M.D. (Representatives of), do.
Purdon, Thomas Henry, M.D. (Representatives of), do.
Patterson, William R., Lower Crescent, do.
*Patterson, R. Lloyd, J.P., Corporation Street, do.
Patterson, William H., M.R.I.A., High Street, do.
Purser, Professor John, M.A., Queen's College, do.
Porter, Drummond, Waring Street, do.
Patterson, Richard, High Street, do.
Patterson, David C., Corporation Street, do.

Riddel, William, Ann Street, do.
Rowan, John, York Street, do.
Ritchie, W. B., M.D., J.P., The Grove, do.
Ross, William A., J.P. (Representatives of), Clonard, Falls Road, Belfast.
Rea, John Henry, M.D., Great Victoria Street, Belfast.
Robertson, William, J.P., Bank Buildings, do.

Simms, F. B., 39, Prospect Terrace, do.
Sinclair, Thomas, M.A., J.P., Tomb Street do.
Suffern, John, Windsor, do.
Suffern, William, Windsor, do.
Steen, Dr. Robert, Ph.D., Academical Institution, do.
Smyth, John, jun., M.A., C.E., Milltown, Banbridge.
Smith, Travers, Sandymount.
Swanston, William, F.G.S., King Street, Belfast

*Tennent, R. J., J.P., D.L. (Representatives of), Rushpark, do.
*Tennent, Robert (Representatives of), Rushpark, do.
Thompson, Robert, J.P., Fortwilliam Park, do.
Thomson, Charles, College Gardens, do.
*Thompson, James, J.P., Macedon, Whiteabbey.
*Thompson, Nathaniel (Representatives of).
*Thompson, William (Representatives of), Belfast.
*Turnley, John (Representatives of), do.
Torrens, James, J.P., Wellington Place, do.

Valentine, James W., Custom House Square,	Belfast.
Valentine, G. F., The Moat, Strandtown,	do.
Workman, John, J.P., Windsor.	
Wilson, James, Old Forge, Dunmurry.	
Walkington, Thomas R , Waring Street,	Belfast.
Workman, William, Corporation Street,	do.
Workman, Rev. R., Newtownbreda.	
Wilson, John K., Donegall Street,	Belfast.
*Wilson, Robert M.	
*Workman, Thomas, Bedford Street,	Belfast.
Wallace, James, Ulster Bank,	do.
Ward, Fras. D., J.P., Bankmore,	do.
Wright, Joseph, F.G.S., Donegall Street,	do.
Workman, Charles, M.D.,	do.
Workman, Rev. R., Glastry, Kirkcubbin.	
Walkington, D. B., Windsor,	Belfast.
Workman, Francis, College Gardens,	do.
Young, Robert, C.E., Donegall Square East,	do.
Young, Robert M., B.A., Donegall Square East,	do.

HONORARY MEMBERS.

Robinson, Hugh, Donegall Street,	Belfast.
Stewart, Samuel A., F.L.S., North Street,	do.
Tate, Professor Ralph, F.G.S., Adelaide, South Australia.	

ANNUAL GUINEA SUBSCRIBERS.

Bruce, James, J.P., Calender Street,	Belfast.
Corry, Sir Jas. P., Bart., M.P., J.P., Dunraven, Windsor,	do.
Craig, James, J.P., Calender Street,	do.
Carr, James, Ulster Bank,	do.
Dinnen, John, Chichester Street,	do.
Dunville, Robert G., D.L., J.P., Calender Street,	do.
Glass, James, Bedford Street,	do.
Graham, O. B., J.P., York Street,	do.

Loewenthal, J., Linenhall Street,	Belfast.
Lynn, William H., C.E., Calender Street,	do.
Lindsay, John, Donegall Place,	do.
Matier, Henry, J.P., Clarence Place,	do.
Milligan, S. F., 1, Royal Terrace,	do.
Mulholland, J. R. T., J.P.,	do.
Murray, Robert, Corporation Street,	do.
M'Auliffe, George, J.P., Calender Street,	do.
M'Causland, John K., Lennoxvale,	do.
Oakman, Nicholas, Prospect Terrace,	do.
Pring, Richard W., Corn Market,	do.
Redfern, Peter, M.D., Professor Queen's College,	do.
Reade, Robert H., York Street,	do.
Rogers, John, Victoria Street,	do.
Seeds, William, Corn Market,	do.
Stannus, A. C., Chichester Street,	do.
Taylor, Sir David, J.P., Windsor,	do.
Tate, Alexander, C.E., Queen's Elms,	do.
Taylor, John Arnott, M.A., Bridge Street,	do.
Watt, R., Victoria Street,	do.
Wolff, G. W., Queen's Island,	do.
Ward, John, F.G.S., Lennoxvale,	do.
Ward, Marcus J., Bankmore,	do.
Young, Samuel, Talbot Street,	do.

Report and Proceedings

OF THE

BELFAST

Natural History and Philosophical Society,

FOR THE

SESSION 1885-86.

BELFAST:
PRINTED BY ALEXR. MAYNE & BOYD, 2, CORPORATION STREET,
(PRINERS TO THE QUEEN'S COLLEGE).

1886.

Report and Proceedings

OF THE

BELFAST

Natural History and Philosophical Society,

FOR THE

SESSION 1885-86.

BELFAST:
PRINTED BY ALEXR. MAYNE & BOYD, 2, CORPORATION STREET,
(PRINERS TO THE QUEEN'S COLLEGE).

1886.

CONTENTS.

Belfast Natural History and Philosophical Society.

ESTABLISHED 1821.

SHAREHOLDERS.

1 Share in the Society costs £7.
2 Shares ,, ,, cost £13.
3 Shares ,, ,, cost £21.

The proprietor of 1 Share pays 10s. per annum; the proprietor of 2 Shares pays 5s. per annum; the proprietor of three or more Shares stands exempt from further payment.

MEMBERS.

There are two classes, Ordinary Members, who are expected to read Papers, and Visiting Members, who, by joining under the latter title, are understood to intimate that they do not wish to read Papers. The Session for Lectures extends from November in one year till May in the succeeding one. Members, Ordinary or Visiting, pay £1 1s. per annum, due 1st November in each year.

PRIVILEGES.

Each Shareholder and Member has the right of personal attendance at all meetings of the Society, and of admitting a friend thereto; also of access to the Museum for himself and family, with the privilege of granting admission orders for inspecting the collections to any friend not residing in Belfast.

Any further information can be obtained by application to the Secretary.

It is requested that all accounts due by the Society be sent to the Treasurer.

The Museum, College Square North, is open daily from 12 till 4 o'clock. Admission for Strangers, 6d. each. The Curator is in constant attendance, and will take charge of any Donation kindly left for the Museum or Library.

BELFAST

Natural History and Philosophical Society.

ANNUAL REPORT, 1886.

The Annual Meeting of the Shareholders of the above named Society was held on the 3rd June, 1886, at three o'clock, in the Museum, College Square North. There were present :—The President, Mr. W. H. Patterson, M.R.I.A. ; Mr. R. L. Patterson, J.P., F.L.S. ; Mr. Robert Young, C.E. ; Mr. Robert M. Young ; Mr. Thomas Workman, J.P. ; Mr. Wm. Gray, M.R.I.A. ; Mr. Wm. Swanston, Rev. John Kinghan, Mr. W. Meharg, and Mr. Isaac Ward.

The Secretary (Mr. R. M. Young) read the report as follows :— " The Council of the Natural History and Philosophical Society, appointed by the shareholders at their annual meeting on the 14th May, 1885, desire to submit their report of the working of the Society during the past year. The winter session was opened on November 3rd, 1885, with an address from your President, Mr. Wm. H. Patterson, M.R.I.A., the subject selected being 'The History and Legends of some Irish Lakes.' The second meeting was held on January 5th, 1886, when Mr. Thomas Workman, J.P., read a paper on 'Eastern Reminiscences, Aden, India, and Burmah.' The lecture was illustrated by a series of admirable photographs and lantern views. The third meeting was held on February 2nd, 1886, when Professor Fitzgerald read a paper on 'The Forth Bridge,' illustrated by a model and diagrams. Mr. Wm. Swanston, F.G.S., also gave a paper on 'Supposed Saurian Remains from the Antrim Chalk.' A short communication by Mr. John Anderson, J.P., F.G.S., on 'A Human Skull Recently Found at Tillysburn,' was also

read. The fourth meeting was held on March 2nd, 1886, when Mr. John Brown read a paper on 'An Experimental Fishing Trip off the North and East Coast of Ireland.' Mr. Seaton F. Milligan also gave a valuable paper on 'The Ancient Civilisation of Peru, including its Textile Industries,' illustrated by a large collection of specimens of woven and dyed fabrics, patterns, personal ornaments, &c., excavated from the Huacas. Samples of modern artistic linen goods were also exhibited for comparison. The fifth meeting was held on April 6th, 1886, when Mr. Joseph J. Murphy, F.G.S., read a paper on 'Wet and Dry Weather,' and Mr. R. Lloyd Patterson, J.P., F.L.S., another on 'A recent Visit to Tory Island,' illustrated by photographs. A short notice of some moths new to Ireland, by Rev. John Bristow, A.M., was also read. Owing to the Parliamentary general election falling about the same date, it was considered advisable to hold no meeting of the Society in December. In addition to these ordinary meetings, your Council arranged for a special series of popular scientific lectures similar to those given in former years. These were well attended, both by members of the Society, who were admitted free, and by the general public. The first of these special meetings was held on January 7th, 1886, in St. George's Hall, when a lecture was delivered by the Rev. J. G. Wood, M.A., F.L.S., on 'Pond and Stream Life.' The second meeting was held on February 4th, 1886, when the Rev. W. S. Green, M.A., gave a lecture on 'My Adventures in the New Zealand Alps.' The concluding meeting of the series was held on March 4th, 1886, in the Ulster Minor Hall, when Mr John Greenhill, Mus. Bac., most kindly gave a lecture on 'Music : Its Science, Theory, and Practice,' with numerous experiments and illustrations.

"It will be seen from the treasurer's report that the financial condition of the Society continues to show improvement. In addition to sale of new shares, all those available which had fallen into arrears within the last six or seven years have been transferred to new holders, who have paid all arrears, and will continue the subscriptions. The number of smaller societies

holding their meetings in the Museum had also greatly increased. The balance now carried forward will, no doubt, enable the Council of next year to carry out some of the much needed work so often deferred for want of funds.

"A list of donations to the Museum and of foreign and home societies, with other publications for the library, is to be printed with the present report The Council would thank the various donors for their valuable gifts, and particularly Lord Claremont for his thoughtful kindness in presenting six volumes of the Ray Society publications and other valuable books. Captain Robert Campbell, of the ship Slieve Donard, has also supplemented his previous generous donations by further interesting specimens collected at foreign ports.

"On Easter Monday the Museum was opened as usual at a nominal charge, and the attendance was, as is always the case, very large.

"The ceiling in the lecture hall, having shown some defects, has been repaired, and some other improvements effected of a trifling kind.

"The library having become overcrowded, arrangements are being made to increase the accommodation for books and pamphlets, of which a large number have been received during the year.

"Your Council now retire from office, and this meeting will be asked to select fifteen members to form a new Council."

The Belfast Natural History and Philosophical Society in Account with Treasurer, For Year ending 1st May, 1886.

Dr. **Cr.**

EXPENDITURE.

		£	s.	d.
To Cash paid	Insurance Premiums	£9	0	0
"	Printing Report	8	4	0
"	Advertising	9	17	3
"	Printing and Stationery	5	4	0
"	Water Rate	3	16	8
"	Repairs to Ceiling of Lecture-room	3	0	0
"	Stamps on Transfer Forms ..	0	10	0
"	Postage	2	3	0
"	Loss on Popular Lecture Account..	7	1	6
"	Rent till 1st May	25	0	0
"	Expenses on Easter Monday ..	6	17	0
"	Collector's Commission	6	8	4
"	W. Darragh, Salary till 1st May ..	48	0	0
"	S. A. Stewart, Salary till 1st May, less ten months' leave, ..	8	6	8
"	S. A. Stewart, Gratuity	5	0	0
"	Fuel and Gas	13	12	8
"	Small Accounts	5	9	10
To Balance	.. ..	33	4	0
		£200	14	11

RECEIPTS.

		£	s.	d.
By	Balance in hands	£10	6	9
"	Interest on Loan to York St. Spinning Co. ..	19	5	11
"	Proceeds of Two Shares Sold	14	0	0
"	Donation	0	8	6
"	Contribution from Philo-Celtic Society, 1884-86	4	13	0
"	Contribution from Beekeepers' Association, 1885-86	1	11	6
"	Contribution from Naturalists' Field Club, 1885-86	5	5	0
"	Contribution from Ulster Photographic Society, 1885-86	1	5	0
"	Transfer Fees	1	7	6
"	Subscriptions	90	16	0
"	Do. Arrears	10	0	0
"	Entrance Fees at door till 1st May ..	15	12	0
"	Do. on Easter Monday ..	26	3	9
		£200	14	11
By Balance	.. ..	£33	4	0

May 24*th*, 1886. Examined and found correct.

WM. H. PATTERSON, SAMUEL ANDREWS, } *Auditors.*

J. BROWN, *Hon. Treasurer.*

DONATIONS TO THE MUSEUM, 1885-6.

From Pearson Anderson Esq., Denver, Colorado.

Specimen of prairie dog or barking squirrel (Conomys Columbianus), shot near Denver.

From Captain Robert Campbell, Master of the Ship "Slieve Donard."

One Malay fighting knife, one pair Afghan boots, one Burmese figure (idol), from the caves at Moulmain, one skin of wild cat, and the skin of the feet of an albatross.

From Miss Grattan, Coolgreany, Fortwilliam Park.

Craniometer used by the late John Grattan Esq., in his craniological researches.

From Mr. J. Kernahan, Glenavy.

Two flint arrow-heads, found near Glenavy.

From Captain W. H. Lowry, Singapore. Per W. H. K. Lowry, Esq., Killyleagh.

One Indian snake preserved in spirits.

From Captain M'Cance, J. P. Knocknagoney, Strandtown.

Human skull found when excavating near the shore at Tillysburn.

From William Swanston, Esq., F. G. S.

Collection of fossil fish remains (66 specimens, representing 36 species) from the carboniferous limestone of Armagh, and a number of molluscan remains from the same beds.

From James Turner, Esq., Mountain Bush.

Portion of vertebral column of mososaurus from the hard chalk of Whitewell.

From Thomas Watson, Esq., Londonderry.

Upper stone of an ancient quern, found at St. Johnston, County Donegal.

From Thomas Workman, Esq., J. P., Craigdarragh.

Specimen of Gecko preserved in spirits.

BELFAST
NATURAL HISTORY AND PHILOSOPHICAL SOCIETY,
SESSION, 1885-86.

3rd November, 1885.

The President, Mr. W. H. Patterson, M.R.I.A., read a Paper on

THE HISTORY AND LEGENDS OF SOME IRISH LAKES.

The leading idea in olden times about a lake was that it came as an intruder to the place in which it rested, and that up to a certain period in the history of the country no lake was there. Regarding the origin of Lough Owel, in Westmeath, there is a legend which tells how a certain fairy or witch who presided over the fertile valley where Lough Owel now rests went on a visit to another witch, who lived in the County of Roscommon, near Athlone, and a very agreeable visit she had till near the end, when her heart became stirred up with envy of a fine lake that the Connaught witch had in her territory, for not only did the lake supply the owner with fish and wild fowl, but by means of it she was enabled to curse her enemies, a practice that witches have been fond of in all times. The cursing was managed by turning certain flat stones at the edge of the water, and ever as the ninth wave lapped over them she pronounced her maledictions. The Westmeath witch determined upon a bold step. She asked for the loan of the lake, saying she wished to see how well it would look in her own valley, and she promised that she

would return it on the very next Monday. The Connaught witch was willing to oblige. "But how, dear, will you take it or send it back?" she asked. "Oh, easy enough; in my pocket-handkerchief," was the answer. And, sure enough, this was the way she managed; and passing safely over Lough Ree and several trifling obstacles, such as rivers and mountains, with a slip of the corner of her handkerchief she let the lake out quietly into the valley of the Owel, where it settled itself as if it had been born and bred there, and there it may be seen to this day; for the Westmeath witch snapped her fingers at her Connaught sister and flatly refused to bring the lake back. Of course there was a terrible row, but the end of it was that the lake was lost to Roscommon for ever, and the former owner had to content herself with as ugly a hollow as anyone ever saw, where once those sweet waters used to flow, all covered with limestone flags as waste as a graveyard. But the lough itself did not like to stay on the Leinster side of the Shannon, and so it sent forth two streams—one from its northern, and another from its southern end—both of which, bounding westwards—and they are called by the people the gold and silver bands—stretched towards Connaught, forming the head waters of the Inney and the Brusna.

However, the Ordnance Survey and the Geological Survey, having passed over the whole of the land, furnished some very clear ideas as to how the lakes of Ireland have been formed. Professor Hull, Director of the Geological Survey, in his work on the physical geology of Ireland, says:—"All the lakes of Ireland may with great probability be classified, as regards their mode of formation, under the three following heads, viz.:—1, lakes of mechanical origin; 2, lakes of glacial origin; 3, lakes of chemical solution." Under the head of mechanical origin, Dr. Hull includes lakes "which, while they may have been modified in form by other agencies, are primarily due to the faults or dislocations of the strata," and in that division he places Lough Neagh and Lough Allen, two remarkable examples of lakes formed in that way.

Dr. Hull says :—"The origin of Lough Neagh has been a subject of much speculation and of some mystery, because, being older than the glacial epoch, it cannot be referred to glacial agency, and, being situated on deposits other than limestones, it cannot be considered as the result of chemical solution. Its proximity to the old volcanic region of Antrim has naturally led to the inference that it was in some way connected with local sinking of the surface through volcanic agency. It was not, however, till the geological structure of the adjoining districts of Tyrone on one side, and Antrim on the other, had been accurately laid down on the maps of the Geological Survey, that a key to the history of its origin was found ; and Mr. W. E. T. Hardman, one of the officers of the Survey, has very ably applied the results of his examination of the district surrounding that lough to the determination of its mode of formation. Its northern portion is bounded by the miocene basalts of Antrim ; its southern, partly by alluvial tracts, partly by masses of drift resting on pliocene clays, which in turn overlie the triassic or carboniferous strata. Its length from north to south is fifteen miles, and its breadth twelve, giving an area of nearly one hundred and fifty square miles. The general depth is only from 20 to 40 feet, gradually increasing towards the northern shore ; and the surface is 48 feet above that of the sea. Mr. Hardman shows that along the southern shores the pliocene clays originally deposited under the waters of the lake rise to a level of 120 feet above the sea, or 72 feet above the existing surface of the lake, showing how much greater the area of the lake must have been in this direction.

"During the progress of the survey it was found that the strata on both sides of the lake are traversed by several large faults ranging in E. N. E. directions. One of these ranges through the basaltic plateau of Antrim by Templepatrick, where the vertical displacement is about 500 feet, the downthrow being on the south side. These faults are later than the basaltic sheets of the miocene age which they displace, and of older date than the pliocene clays, which are not affected by them,

the ground having been smoothed down, and the inequalities caused by the dislocation of the beds having been worn away, by denuding agencies before the clays were deposited. It was to the depression of the surface through the agency of these faults that, according to Mr. Hardman, the formation of the lake is due. This lake, therefore, forms an illustration of a basin formed by the mechanical action of faults in the strata, assisted by the action of running water."

Lakes of glacial origin are found in many parts of Ireland, but chiefly among mountain glens and in front of valleys. These lake-basins are hollow, scooped out of the rock by the action of ice passing over its surface, or else, as Dr. Hull has pointed out, "where moraine matter or boulder clay has been heaped up across a valley or hollow so as to form an embankment for the streams which enter the depression from above." The class of lakes which are due to chemical solution are chiefly found in the great central plain of Ireland, but they are met with in all limestone districts. They are, "strictly speaking, irregular hollows dissolved out of the limestone floor and filled with water." Dr. Hull says that in examining the form of these lakes of chemical solution, "from the manner in which they widen out in some places, and in others become contracted, it will generally be found that they spread themselves out over the ground formed of limestone, and contract where non-calcareous rocks form the bed and margin of the lake. Lough Derg is an illustration of this."

Mr. Patterson then directed attention to the mention made in the "Four Masters" concerning the eruption of lakes, the first eruption being in the year of the world 2532. The passage, as translated by O'Donovan, reads—"The age of the world 2532. The eruption of Loch Con and Loch Techet in this year." O'Donovan explains that Loch Con is a large lake in the barony of Tirauley, and County of Mayo. In the age of the world 3506 the eruption of a large number of the Irish lakes took place. Amongst these was Loch Laogh, the ancient name of Belfast Lough, and which means in Irish the Lake of the Calf. The early monkish writers translated the name into

Latin, and called it Lacus Vituli. In the concluding portion of the lecture Mr. Patterson brought under the attention of the meeting a most interesting collection of legends concerning many of the Irish lakes. There were two aspects in which the Irish loughs must be considered when looked at historically. In connection with the many invasions of Danes and Northmen mention was made of the terrible sea fights that had often occurred. Such loughs as Foyle and Swilly, Larne and Belfast, Strangford and Carlingford, Waterford, Wexford, and the estuary of the Shannon, were so many open gates by which these sea rovers entered our country, and from whence they ascended by the river valleys to the more central parts of the island. The other aspect, which he could only mention, was that of the fortified islands, of which such numbers exist in the smaller Irish lakes, most frequently artificial ones, or crannogs. These crannogs were the strongholds of provincial chiefs. They were places of great security, and took the same place among the Irish as the stone castles of the Anglo Normans among the English of the Pale.

5th January, 1886.

MR. JOSEPH J. MURPHY, in the Chair.

MR. THOMAS WORKMAN, J.P., read a Paper on

EASTERN REMINISCENCES—ADEN, INDIA, AND BURMAH.

Mr. Thomas Workman stated that his lecture was a continuation of a former one, descriptive of his voyage to and residence in different parts of India and Burmah. He commenced by a description of the shores of the Red Sea, referring to the gorgeous colouring of the mountains which crown them. One of these mountains is the famous three-peaked Jebel Katharina, better known by its ancient name of Mount Sinai. The Red Sea, though fog or snow are utterly unknown and storms are very rare, is, nevertheless, one of the most dangerous seas known to navigators, and in it the seaman is never free from anxiety on account of the haze and mirage which prevail. At the island of Perim, where the Red Sea narrows to the straits of Bab-el-Mandeb, or the Gate of Tears, the hulls of many steamers may be seen along the shore as warning beacons to the careless navigator. Its name of Gate of Tears is said to have been given to it because of the disasters sailors met in its vicinity. A short distance round the projecting coastline from the straits of Bab-el-Mandeb is the port and town of Aden, which in Arabic means Paradise, though to the British traveller another name would seem more suitable. The town is situated in a valley—apparently the crater of an extinct volcano—and is surrounded by

mountains of volcanic trap, without vegetation. The water for the supply of the town is collected in the rainy season, in enormous tanks, formed by walls of concrete built across the lower ends of the valleys. In the Bay of Aden the weather is usually lovely. Many beautiful jelly-fish, of every possible hue, may here be seen "within the shadow of the ship"—

> "Blue, glossy green and velvet black,
> They coiled and swam, and every track
> Was a flash of golden fire."

The town and precincts of Colombo, in the island of Ceylon, are exceedingly interesting, both from the richness of the tropical scenery and the picturesqueness of the Kanarese, as the natives of Ceylon are called. The native boats, which are long and narrow, and have a curious outrigger to keep them from capsizing, have always attracted attention from the passing traveller, both from their peculiar construction and their great speed. The Mohammedans have a legend that the Garden of Eden was in heaven and not on earth, and that when Adam and Eve were cast out Adam fell on Adam's Peak, the highest mountain in Ceylon, where the mark of his foot can be seen at the present day to attest the truth of the legend. Eve, they say, fell somewhere else, and she and Adam went about the world for 200 years seeking for one another. Fortunately, by a happy accident, they met in the neighbourhood of Mecca, after an amount of journeying to which the wanderings of Evangeline were but a trifle. The lecturer next gave an account of a visit to the temple of Kali, at Calcutta, and a description of the effigies and pictures of this hideous goddess and her fabled attributes. Kali or Kali Ma—"the black mother," as she is called—is represented as a female with four arms. In one she holds a sword, in another the head of the giant Ravena, whom she has slain; with the other two she is encouraging her worshippers. For earrings she has two dead bodies, and she wears a necklace of skulls. Her only clothing is a girdle made of human hands. She stands with one foot on the thigh and the other on the breast of her husband Siva. It seems impossible to realise that such a hideous figure could be an object of reverence or love to any human being.

The lecturer made some observations on the serious danger of a State education that refuses to deal with religion. Though the Hindu religion seems so terribly degrading that one might at first sight be inclined to say that no religion would be preferable to it, yet it is a grave question whether human nature is not better with a religion of a very low type than without a religion at all, and, of course, when our scientific education comes to these people their present faiths must disappear, leaving nothing under the present system to take its place but blank atheism.

The lecturer described his journey, after leaving Calcutta, to British Burmah, and his visits to the three principal towns—Rangoon, Bassein, and Moulmein. He was much impressed with the enormous size and magnificence of the Showay Dragon Pagoda, or great golden temple of Godama, at Rangoon. The area on which this pagoda stands is 800 feet square. The entrance is approached by an enormous flight of stairs, which is guarded by two huge mystical figures about fifty feet high, with blue heads and red mouths. The pagoda itself is a stupendous mass of solid masonry tapering gradually from an octagonal base, 1,355 square feet in extent, to a spire of small circumference, surmounted by the sacred "tie" or umbrella, of open ironwork. The umbrella is said to be studded with jewels of very great value, and the whole building is one blaze of gold. The "Pooh Yees," or Buddish priests, dress in a long yellow garment, and live in monasteries called kouyns, made of wood, and richly carved. At Maybin, a village on the Irrawaddy, the mosquitoes are so fierce and numerous that large fires have to be lighted by the natives in the evening to keep them away, and even the horses and milch cows are sheltered by mosquito nets. The Burmese seem to lead a quiet, contented life, and, as far as one can judge, are fairly satisfied with the British rule. The women, unlike their sisters in India, are allowed much freedom by social custom, and many of them take an active and independent interest in business affairs, such as the sale of rice and other produce.

Mr. Robert L. Patterson, J.P., F.L.S., said they were all indebted to Mr. Workman for his interesting lecture. Mr. Workman did not appear to have ventured very far into the interior, but the information he had been able to gather was particularly interesting just now, as the attention of everybody in this country had lately been attracted to the action of the British Government in Burmah, and in annexing upper Burmah, in order to put an end to the misrule, the bloodshed, and the cruelty that had obtained there. A friend of his who visited Burmah last year told him a rather curious circumstance, which, in connection with what they had heard that evening, it might not be uninteresting to repeat. Mr. George Burns, of Glasgow, being in Burmah, wished to pay a visit to Mandalay, but was informed that the journey was not unattended with some risk. However, he determined to go. He discovered that on the Irrawaddy navigation could only be carried on by day, as the river was not lighted and was full of obstructions. The journey occupied ten or eleven days. One night they observed a curious object on the shore at some distance from the water edge, and on their going near it they were horrified to find that it was a man who had been crucified that morning. He (Mr. Patterson) was unaware until he learned this that the horrible punishment of death by crucifixion obtained in any country, even in an uncivilised country, at the present day. The man crucified was a dacoit or robber, who, as a rule, scrupled little about committing murder for the purpose of accomplishing their ends. After the dacoit was crucified he had been speared to death, and the vultures were at the time gathering to pick his bones. Mr. Burns, when in Mandalay, had an interview with the Prime Minister, but he was not given an interview with the King. Mr. Burns described the country as being very fertile, and was of opinion that it only required a strong and stable government to bring it to a state of civilisation, in order to make it a good customer of ours. Such a government, he hoped Burmah would have in the future.

3rd February, 1886.

Mr. W. H. Patterson, M.R.I.A., in the Chair.

Professor Fitzgerald read a Paper on

THE NEW BRIDGE OVER THE FIRTH OF FORTH,

Which is now in process of erection.

Having stated briefly the greater difficulties which presented themselves in the task of bridging the Forth than even those which had proved so seriously formidable in the Tay, Prof. Fitzgerald said that the former work when finished will be the largest girder bridge in the world, there being no other bridge of that class having so wide a span. The engineer, Mr. Baker, had very considerable difficulties in selecting a design that could be actually carried out. The great difficulty to be dealt with in constructing bridges of long span is the weight of the bridge itself. By means of steel, though not steel of the ordinary kind, being more like fine wrought iron, that primary difficulty was overcome. In large bridges the weight increases faster than the strength, and the advantage of steel is that it gives greater strength than iron, with the same weight. The entire length of the new bridge will be about one mile, and the main span 1,700 feet. The Admiralty required that the bridge should be 150 feet above the water. The depth of the water itself is 150 feet. The foundations rest on solid rock in some parts, and in others in a peculiar clay.

The lecturer then entered into a detailed description of the

character of the foundations and the process by which they were laid. He showed that every test to provide for resistance to wind pressure was being applied. The main span is supported by two huge piers—one at Inchgarney Island—each pier being composed of four towers as large as four ordinary martello towers rolled into one. Having described the plan followed in the forming of the piers and the supports carrying the girders, the Professor, in order to illustrate by a familiar example the extraordinary dimensions of the bridge, supposed an observer standing at the Methodist College looking at a bridge extending to the military barracks in North Queen Street, the rail-level being as high again as the Albert Memorial. He also applied a map of the Boyne Viaduct to the map of the Forth Bridge, and it was seen that the entire of the former structure could be easily accommodated within the main span of the latter. The cost of the new bridge will be about £1,600,000, and the work will probably be completed at the end of two years from the present time.

3rd February, 1886.

The President, Mr. W. H. Patterson, M.R.I.A., in the Chair.

William Swanston, Esq., F.G.S., read a Paper upon an

IMPORTANT LOCAL GEOLOGICAL DISCOVERY.

Mr. Swanston stated that the notes he had been requested to bring forward referred to a fossil that had been found some time since in the white limestone, or chalk, quarry at Whitewell, and which had now been presented to the Museum by the proprietor (Mr. Turner, of Mountain Bush). The fossil was portion of the vertebral column of a huge reptile, known to the geologists as *Mosasaurus gracilis*, of Owen, and whose nearest living representative is the crocodile. *Mosasaurus gracilis* belonged to a family of giants, remains of specimens having been found that must have measured fully 25 feet in length ; while its better known relative, *Mosasaurus princeps*, attained the extraordinary length of 75 feet. The first record of our species as British was made by Dr. Mantell, in his "Geology of the South-East of England." Detached fragments have from time to time since been found in English and Continental strata, and from these it has been pretty clearly made out that the creature's head formed about one-sixth of its entire length, in which respect it resembled the crocodile, but in the shortness of its tail and other respects it was altogether unlike it. From the examination of its remains it can be pretty safely conjectured that it was aquatic and possibly marine in its habits. Its feet were paddle-like in form —more adapted for swimming than for progression on land ;

its vertebral column, too, from its apparently extreme flexibility, would tend to confirm this view. The specimen on the table was extremely interesting, as being—so far as can be traced—the first fragment from Irish strata, and from the additional reason that it tends to confirm the view long since advanced that our chalk may be considered as perhaps the highest member of the cretaceous system in the British Islands, and most nearly correlated with the chalk of Maestricht, in Belgium, in which this species attained its maximum of development, and which is considered the highest known zone of the cretaceous system.

A HUMAN SKULL FOUND AT TILLYSBURN.

Mr. Robert M. Young, B.A., read a communication from Mr. J. Anderson, J.P., Holywood, regarding a human skull which had been found on the 17th January by Captain M'Cance, J.P., about eighteen inches below the surface of the slob, some ten or twelve yards inside the railway embankment, and immediately at the foot of Captain M'Cance's windmill.

Dr. Malcomson, taking the skull in hand, stated to the meeting that the skull was apparently that of a man sixty years of age, and had been dead for probably fifty years. Although it had been suggested that some violence was used to the person who owned the skull, he did not think there was any mark to justify that opinion.

2nd March 1886.

Mr. W. Swanston, F.R.G.S., in the Chair.

Mr. John Brown read a Paper on

AN EXPERIMENTAL FISHING TRIP OFF THE NORTH AND EAST COASTS OF IRELAND.

Mr. Brown said that in 1882 he purchased a small steam vessel for the purpose of trawling off the Irish coasts. He had tried most of the trawling grounds along the coast from St. John's Point to Innishowen Head, but without sufficient success on the whole to warrant a continuation of the enterprise. Lough Foyle and the banks outside it were perhaps the best places he had tried. He referred to the decadence of fishing in Belfast Lough, and believed it was due to the trawling on the upper flats and banks in the lough, by which large quantities of small fish were taken, which brought only a nominal price, and such fish were prevented from attaining maturity in the lower portion of the lough. He suggested that one or other of the scientific societies of Belfast should take this matter up, obtain evidence from the fishermen, and, if desirable, take steps to have the upper part of the lough closed to trawlers.

The paper was suitably illustrated with nets and other fishing tackle suspended in the room.

2nd March, 1886.

Mr. W. Swanston, F.R.G.S., in the Chair.

Mr. Seaton F. Mulligan read a Paper on

THE ANCIENT CIVILISATION OF PERU, INCLUDING ITS TEXTILE INDUSTRIES.

Mr. Mulligan illustrated his lecture with a very interesting and valuable collection of woven and dyed fabric patterns and personal ornaments. This collection of Peruvian antiquities was brought to Ireland by a friend of the lecturer, whose duties as an engineer in Peru gave him opportunities to gratify his archæological taste, and in so doing to make excavations in the ancient Huacas of the people who inhabited that country in ante-Columbian times. Having given a sketch of the civilisation of the ancient Peruvians, the lecturer said he had been requested to compare our modern productions with the ancient fabrics of Peru. There are some lessons to be learned from those ancient fabrics, and there are lessons to be learned from our foreign competitors in the same field. The Ulster manufacturers have not yet got the linen trade of the world entirely to themselves, and it would be well to know what their opponents are doing. The ancient cloths seem to have been finished in the most perfect manner. How different from the fustian of the present day. A very few years ago Manchester goods were almost unsaleable in the India and

China markets, for the natives found their home-made calicoes much better, and the outcry that was raised at the time taught the Manchester manufacturers that honesty was the best policy. During the American war the linen trade in Belfast was particularly good. Cotton could not be procured, and linen had to make up the deficiency. To supply the place of domestic calico a kind of half bleached linen was introduced. No doubt, so far as home consumption was concerned, a splendid opportunity was lost of placing the linen trade on a more extended basis. When cotton again became plentiful it was bought in preference to linen. It seemed to him that we do not sufficiently introduce art in connection with our local linen manufacture, the bulk of our production being plain goods. This did very well so long as a good demand existed for white goods, but unfortunately the white linen trade has been a decreasing one. As far as his experience goes, in the home trade there is not one piece of white linen sold in Ireland for the dozen pieces sold twenty five or thirty years ago. People now order their shirts from the manufacturers, and the latter have introduced a variety of other fabrics which have taken the place of linen. The peasantry of Connaught, who are very conservative in the matter of clothing, are the only people in the country who to any extent wear white shirts. He had brought with him a variety of samples of linen goods, and goods made of linen and cotton, in which a considerable amount of skill and artistic taste was displayed. These goods are made in Germany, and are sold by the agents of German houses both in England and Ireland. The Germans are now pushing the English manufacturers very close in many things. There is in this country a favourable opening for dress fabrics in linen, and mixtures of linen and cotton. For some time past the Irish people have given the preference to home made goods of a suitable kind. There has not been much done in Belfast in this direction yet, and he thought there would be a considerable outlet if some good designs were introduced.

THE OLD GATE AT CARRICKFERGUS.

On the motion of Mr. Gray, seconded by Mr. Mulholland, it was resolved that this Society co-operate with the Naturalists' Field Club in opposing the intended action of the Grand Jury to remove the old gate at Carrickfergus.

THE OLD CROSS AT DROMORE.

The Chairman intimated that he had received from one of the Dromore Town Commissioners a letter stating that the old cross of that town would be preserved in the changes that were about to be made, and that the wishes of the Naturalists' Field Club in the matter were being carried out.

6th April, 1886.

The President, Mr. W. H. Patterson, M.R.I.A., in the Chair.

Mr. Joseph John Murphy, read a Paper on

WET AND DRY WEATHER.

The treatment of the subject was chiefly based on some publications by Dr. Hann, printed in the journal of the Austrian Meteorological Society.

The motive power of all winds ultimately consists in the heat of the sun. When one region becomes warmer than another, as, for instance, land heats more rapidly under the sun than water, or bare ground than ground covered with vegetation, the air flows upward over the heated space, and a wind is formed by the inflow of air along the surface of the earth ; just as the fire in a room draws the air towards it in a draft along the floor. The trade winds consist of such a draft towards the warm regions of the equator.

Storms, as distinguished from mere winds, are due to the condensation of watery vapour in ascending currents of air. When air flows upward the pressure on it from the air above is diminished, because of the less thickness of the aerial strata above it ; the diminution of pressure causes expansion, and the expansion produces cold, whereby the heat that was latent in the vapour is liberated :—and though when vapour is condensed into water the volume of the water is destroyed, yet this is compensated for four or five times over by the liberated heat expanding the air ; which expansion increases the force of the ascending current, and the consequent indraft of wind at its base. The motive power of storms is thus steam power. But storms would not be produced but for another agency, namely, the earth's rotation ; which, though it has no power whatever to set a wind in motion, has a most important modifying influence on winds, as is to be explained further on.

The pressure of the atmosphere on the earth is equal to that of an ocean of quicksilver thirty inches deep, and it is a fact which from its familiarity does not excite the wonder due to it, that this atmospheric ocean is liable to be disturbed by waves, which, as the barometer shows, sometimes attain to a height of at least one fifteenth of its depth. Regions of high barometer are generally those of fine weather, and regions of low barometer those of wet weather, because in the latter ascending currents of air are formed, which are due to the pressure of the air in the neighbouring regions of high barometer. These as they ascend become cooled, and condense the watery vapour which they contain into clouds and rain. At the equator, where the rain-fall is very great, the fluctuations of the barometer are very slight, and it would be the same in all parts of the world were it not for the deflecting effect of the earth's rotation. The simplest instance of this effect is that, as theory and observation alike show, in the northern hemisphere a cannon ball fired at a sufficiently distant mark strikes a point a little to the right of the mark. In the southern hemisphere the corresponding deflection is to the left; and at the equator, where the earth has no rotation in relation to an axis vertical to the horizon, there is no deflection. The deflection is caused by the earth moving in its rotation under the cannon ball; the cannon is in fact fired at a moving mark;—and in the same way, the earth rotating under a current of wind deflects the wind in the northern hemisphere to the right; so that every north wind tends to become an east wind, and every south wind tends to become a west wind. In the southern hemisphere, this effect is of course reversed. This effect of the earth's rotation on the winds was first pointed out by Professor Dové, of Berlin, forty or fifty years ago, and is called Dové's Law; but Mr. Murphy said he believed Dr. Hann had been the first to see the full importance of this law. Theory and observation alike show that the fluctuations of the barometer increase as the distance from the equator increases. They are almost nothing at the equator. At a latitude of 65 the average monthly fluctuation is nearly an inch and a half.

When the most powerful ascending current, and consequent indraft, are set up at the equator, no storm is produced ; but when the same occurs far enough from the equator to enable the earth's rotation to have effect, every current of air as it flows in towards the centre is deflected to the right (or, in the southern hemisphere, to the left), and thus a vortex, or cyclone, is formed, with a rotatory velocity which may be very much greater than the original velocity of indraft. This may be illustrated by filling a wash-hand basin with water, removing the plug at the bottom, and then giving the water a slight rotatory impulse with the hand, when the water will begin to rotate with an impulse very much greater than the force with which it was set in motion. The mechanics of such a water vortex, or whirlpool, closely resemble those of a cyclone or revolving storm ;—the ascending current at the centre of the storm corresponds to the current out through the hole in the bottom of the water basin. Although the earth's rotation in relation to an axis vertical to the horizon is less in tropical than in European latitudes, yet the storms of the tropics are more violent, in consequence of the greater steam power of the atmosphere, due to the hotter climate. On the equator, however, cyclones are not found, because there the earth's rotation does not deflect the wind, either to right or to left.

Dr. Hann has made a mathematical examination of the observed data of some European storms, which shows that the barometric gradient—that is to say the ratio of the difference between the height of the barometer at different places to the distances between those places—is greater than is due to the centrifugal force generated by the rotation of the storm, and he infers that the excess is due to the deflecting force of the earth's rotation.

Mr. Murphy concluded by expressing the opinion that the origin of those fluctuations of the barometer, or barometric waves, which accompany and bring storms, is to be found in the inter-action of currents of air flowing side by side in opposite directions, modified by the earth's rotation.

6th April, 1886.

The President, Mr. W. H. Patterson, M.R.I.A., in the Chair.

Mr. Lloyd Patterson, J.P., F.L.S., read a Paper on

A RECENT VISIT TO TORY ISLAND.

Some merchants and shipowners of Derry, prominent among whom was Mr. James M'Neil, of that city, conceived the idea that it would be a very important matter, not only for the shipping interest, but also for the country at large, that a telegraph and signal station, connected by sub-marine cable with the telegraph system of the United Kingdom, should be established at Tory Island to report passing vessels, being able to communicate with the mainland in case of any shipping disaster or peril, and for such and kindred purposes generally. A meteorological station was also spoken of. Now, as to the value of the signal station there can hardly be two opinions. Situated, as the island is, off the north-west coast of Donegal, it lies in the track of all vessels going north about from any port in the United Kingdom to any port in America. It is the last land they see on their outward voyages, and often the first land they make on their homeward runs. A number of wrecks formerly took place on the island, but these have greatly diminished since the erection there, in 1832, of what was then considered a very fine lighthouse. This lighthouse, one of the usual tower shape, and of enormous strength, is pretty lofty; its lantern, a powerful one, stands 122 feet above the high-water level of the sea, and is visible at a distance of seventeen or

eighteen miles in fair weather. The Commissioners of Irish Lights have been improving and re-erecting lighthouses at various important points round the coasts, and Tory is now having their attention. But I am unable to say whether or not this had been decided on prior to the loss of the gunboat Wasp on the island on the 22nd September, 1884. This melancholy event, by which no fewer than 52 persons lost their lives, directed much attention to this lonely island, and invested it with a melancholy interest at the time of our visit. Had a powerful siren, such as has lately been erected on Ailsa Craig, been then in existence at Tory to warn off vessels in thick weather when the light cannot be discerned, the loss of that vessel and so many of her gallant crew might have been averted. Well, it was to awaken more general interest in the establishment of such a signal station, the utility of which, both from a practical and humane point of view, I think, had been demonstrated, that Mr. M'Neil organised the trip to the island, in which it was my good fortune (as representing, at the request of its President, my friend Mr. Megaw, the Belfast Chamber of Commerce) to take part. After glancing briefly at the early history of the island, Mr. Patterson went on to give an account of his personal experiences of the place, as related by him shortly after the visit in the columns of the *Northern Whig.* Referring to the vicissitudes which the inhabitants of the island have suffered from time to time, he said in unfavourable seasons it is next to impossible for the small amount of arable land to produce food enough for even a small population. In recent years more than once the people were reduced to the verge of starvation. On one occasion a severe gale swept immense waves over the island, and carried the greater portion of the crop of corn, which had been partially cut, but not housed, into the sea, washed the potatoes out of the ground, and rendered the fresh water undrinkable ; and on other occasions a more or less partial failure of the crops left the poor people partially dependent on the outside world for the supplies which nature denied them at home.

Kelp burning was formerly carried on on the island to a considerable extent. This product of the sea, fresh out of the strong, deep waters of the North Atlantic, was rich in iodine, and found a ready market at remunerative prices in the great chemical works at Glasgow, to which port it was conveyed by the Sligo steamer calling off the island. But the demand for kelp has fallen off, and prices have become so low that it is no longer produced, and the island can export little now except lobsters, as it is difficult to get a quick market for perishable fresh fish, such as mackerel.

There are about fifty houses or families and about 350 or 360 inhabitants on the island. In 1841 the population was returned at 391 males and 200 females, and at that time there were eighty inhabited houses. Speaking of the social condition of the people, he said—There is not a policeman in the place, and there seems to be little or no social distinction as among the people themselves. Till lately there was a "King" of Tory, so called because the other islanders acknowledged his authority and bowed to his decisions in the settlement of disputes; but since the decease, now some years ago, of the last monarch, the authority in such matters seems to have passed into the hands of the resident Catholic curate, the island being in the parish of Cloughnahuly, on the mainland of Donegal. The parish priest here, Rev. Mr. M'Fadden, has two curates, each of whom, it is said, takes about a six months' turn on the island and then on the mainland.

The people pay no taxes. A few years ago the grand jury of Donegal proposed to levy county cess on the island—a gross injustice, as the people make, practically, no use whatever of the roads and bridges of the mainland, and they have none of their own to keep in repair. This unreasonable demand was not persisted in. The rent question is different. The rental of the island, including one penny per annum for the grazing of each sheep, used to be about £240 a year. When good prices were no longer obtainable for kelp the people were unable to pay their former rents, and made, through their

clergyman, an offer of £100 a year to the present proprietor of the island, the Rev. B. St. John Joule. This offer the agent declined ; and since then, five or six years ago, the people have paid no rent at all, and do not apparently expect to have to pay any more. I have a copy of some very acrimonious correspondence that passed between the landlord and others on this subject. The matter seems to have ended—at least for the present—in the landlord's rights being entirely set aside.

Before concluding, let me take a brief glance at the island. Its surface, including three small lakes, two of them brackish, comprises about 1,200 acres, of which perhaps less than one-sixth may be under cultivation. Of wild quadrupeds there are only two—the rabbit and the common mouse—found. There are no reptiles—not even a frog; and except the sea fowl in the breeding season, when they are numerous, not many birds, and those almost exclusively ground or cliff breeding birds, as there is not a tree and hardly a bush on the island for the arboreal species. I saw some wheatears, buntings, sparrows, and pipits, grey crows, and starlings—the two latter probably visitors from the mainland. The storm petrel still breeds there ; but, from what I could gather, not in the same numbers as they were found by Mr. Hyndman and his companions in 1845. The person I was speaking to about them knew the birds quite well, and called them "Mother Carey's Chickens." There are a good many poultry and domestic animals on the island; among these some small sized horses, which are used sometimes with panniers, one suspended on each side, or sometimes in carts without wheels, "slipe" carts as they are called. The shafts of these carts are lengthened backwards, and drag along the ground. Mr. Patterson concluded a highly interesting paper by relating a humorous story by the Rev. John Brown concerning the introduction of the horse into Tory.

A number of photographs, taken by Mr. Stelfox during the visit, were exhibited.

BELFAST

Natural History & Philosophical Society.

Officers and Council of Management for 1885-6.

President:

W. H. PATTERSON, Esq., M.R.I.A.

Vice-Presidents:

ROBERT MacADAM, Esq.
THOMAS WORKMAN, Esq., J.P.
Prof. E. A. LETTS, Ph.D.
JOSEPH WRIGHT, Esq., F.G.S.

Treasurer:

JOHN BROWN, Esq.,

Librarian:

THOMAS WORKMAN, Esq., J.P.

Secretary:

ROBERT M. YOUNG, Esq., B.A.,

Council:

PROFESSOR E. A. LETTS, Ph. D.
PROFESSOR R. O. CUNNINGHAM, M.D.
W. H. PATTERSON, Esq., M.R.I.A.
ROBERT MacADAM, Esq.
PROFESSOR J. C. EVERETT, F.R.S.
R. L. PATTERSON, Esq., J.P., F.L.S.
THOMAS WORKMAN, Esq., J.P.
ROBERT YOUNG, Esq., C.E.
JOSEPH WRIGHT, Esq., F.G.S.
JOHN BROWN, Esq.
J. H. GREENHILL, Esq., Mus. Bac.
JOSEPH JOHN MURPHY, Esq.
WILLIAM SWANSTON, Esq., F.G.S.
JAMES WILSON, Esq., M.E.
R. M. YOUNG, Esq., B.A.

SHAREHOLDERS.

[* *Denotes holders of three or more Shares*].

*Alexander, James, J.P. (Representatives of), Holywood.	
Allen, R. H., Mus. Bac., College Green,	Belfast.
Anderson, John, J.P., F.G.S., Hillbrook, Holywood.	
Andrews, Elizabeth, College Gardens,	Belfast.
Andrews, George, Ardoyne,	do.
Andrews, Samuel, J.P., Seaview,	do.
Archer, Henry, Orlands, Carrickfergus.	
Barbour, James, Ardville, Marino.	
*Batt, Thomas G. (Representatives of), Stranmillis,	Belfast.
Bland, Robert H., Woodbank, Whiteabbey.	
Bottomley, Henry H., Hughenden, Fortwilliam Park,	Belfast.
*Bottomley, William, J.P.,	do.
Boyd, William, Great Victoria Street,	do.
Boyd, William Sinclair, Ravenscroft, Bloomfield,	do.
Brett, Charles H., Gretton Villa South, Malone Road,	do.
Bristow, James R., The Park, Dunmurry.	
Brown, John Shaw, J.P., Edenderry House,	Belfast.
Brown, John, Jun., Bedford Street,	do.
Brown, William K., Rushmere,	do.
Burden, Henry, M.D., Alfred Street,	do.
Burnett, John R., Martello House, Holywood.	
Calwell, Alex. M'D., College Square North,	Belfast.
*Campbell, Miss Anna, Howard Street,	do.
Campbell, John, Lennoxvale,	do.
Carson, John, Church Lane,	do.
*Charley, John (Representatives of), Finaghey,	do.
*Charters, John (Representatives of),	do.
Clarke, Edward H., Elmwood House,	do.
*Claremont, Lord, Ravensdale Park, Newry.	
Coates, Victor, J.P., Rathmore, Dunmurry.	

Connor, Charles C., Nottinghill House, Belfast.
Crawford, William, Calender Street, do.
Cuming, James, M.A., M.D., Wellington Place, do.
Cunningham, Robt. O., M.D., F.L.S., College Gardens, do.

*Deramore, Lord, D.L., Belvoir Park, do.
*Donegall, Marquis of.
*Downshire, Marquis of, Hillsborough Castle.
Drennan, John S., M.D., Prospect Terrace, Belfast.
*Drummond, Dr. James L. (Representatives of), do.
Duffin, Charles, J.P., Strandtown Lodge, do.

Emmerson, William, Donegall Quay, do.
Everett, Joseph D., M.A., D.C.L., F.R.S., Lennoxvale. do.
Ewart, Lavens M., J.P., Glenbank House, do.
Ewart, William, J.P., M.P., Glenmachan House, Strandtown.
Ewart, William Quartus, Schomberg, Strandtown.

Fagan, John, M.D., F.R.C.S.I., Glengall Place, Belfast.
*Fenton, Samuel G., J.P., Windsor, do.
Ferguson, Henry, M.D., Fisherwick Place, do.
Finlay, William Laird, Arlington, Windsor, do.
Finlay, William Laird, Jun. (Representatives of), do.
Fitzgerald, Professor Maurice, Botanic Avenue, do.
Forsythe, Robert H., Holywood.

*Getty, Edmund (Representatives of), Belfast.
Girdwood, H. Mercer, Broughton Maxwell, Manchester.
Gordon, Alexander, M.D., Fitzroy Avenue, Belfast.
Gordon, Robert W., J.P. Summerfield, Dundonald.
*Grainger, Rev. Canon, D.D., M.R.I.A., Broughshane, Ballymena.
Gray, William, M.R.I.A., Mountcharles, Belfast.
Greenhill, John H., Mus. Bac., Richmond Terrace, do.
Greer, Thomas, J.P., Seapark, Carrickfergus.

*Hamilton, Hill, J.P. (Representatives of), Mountvernon, Belfast.
Hamilton, Sir James, J.P. (Representatives of), do.

Harland, Sir E. J., Bart., J.P., Ormiston, Strandtown, Belfast.
Heburn, William, Clonard Mill, do.
Henderson, Miss Anna S., Windsor Terrace, do.
Henderson, James, A.M., Norwood Tower, Strandtown, do.
Henderson, Robert, High Street, do.
*Henry, Alexander, Manchester.
Herdman, John, J.P., Carricklee House, Strabane.
*Herdman, John (Representatives of), Belfast.
Heyn, James, A.M., Ulster Chambers, do.
Hind, James (Representatives of), do.
Hind, John, J.P., do.
Hind, John, Jun., College Street South, do.
Hodges, John F., M.D., F.C.S., J.P., Derryvolgie Avenue, do.
Hogg, John, Academy Street, do.
Holford, Thomas & Arthur, Cern Abbas, Dorsetshire.
*Houston, John Blakiston, J.P., D.L., Orangefield, Belfast.
Hyndman, Hugh, LL.D., Livingstone Terrace, do.

Inglis, James, Abbeyville, Whiteabbey.

Jackson, Thomas, C.E., Altona, Strandtown, Belfast.
Jaffé, John, J.P., Edenvale, Strandtown, do.
Jaffé, Otto, Canadian Villas, Strandtown, do.
*Johnson, Sir William G., J.P., D.L., College Square North, do.
Johnston, Samuel A., Dalriada, Whiteabbey.

Keegan, John J., Brooklyn, Holywood.
Kennedy, James, Richmond Lodge, Belfast.
Kennedy, William, College Park East, do.
*Kinghan, Rev. John, Altona, Windsor, do.

Lanyon, Sir Charles, J.P., The Abbey, Whiteabbey.
Lemon, Archibald Dunlop, J.P., Edgecumbe, Belfast.
Lepper, F.R., Ulster Bank, do.
Letts, Professor E. A., Ph.D., F.C.S., Viewmount, Windsor, do.
Lytle, David B., University Square, do.

*Macrory, A.J. (Representatives of),	Belfast.
Malcolm, Bowman, Richmond Crescent,	do.
Meharg, James, Ardlussa,	do.
*Mitchell, George T. (Representatives of),	do.
Mitchell, W. C., J.P., Ardilea,	do.
Montgomery, Thomas, J.P., Ballydrain House,	do.
Moore, James, J.P. (Representatives of), Craigavad.	
Moore, James, College Gardens,	Belfast.
*Mulholland, Andrew, J.P. (Representatives of),	do.
Mulholland, John, J.P., D.L., Ballywalter Park.	
Mullan, William, Lindisfarne, Marlborough Park,	Belfast.
Murney, Henry, M.D., J.P., Donegall Square South,	do.
*Murphy, Isaac James, Armagh.	
*Murphy, Joseph John, Osborne Park,	Belfast.
Murray, Robert Wallace, J.P., Fortwilliam Park,	do.
Musgrave, Edgar, Drumglass, Malone,	do.
*Musgrave, Henry, Drumglass, Malone,	do.
Musgrave, James, J.P., Drumglass, Malone,	do.
MacAdam, Robert, College Square East,	do.
*M'Calmont, Robert, London.	
*M'Cammon, Thomas, Dublin.	
M'Cance, Finlay, J.P., Suffolk, Dunmurry.	
*M'Cance, J. W. S. (Representatives of), Suffolk, Dunmurry.	
M'Clure, Sir Thomas, Bart., J.P., V.L., Belmont,	Belfast.
*M'Cracken, Francis (Representatives of), Donegall Square,	do.
M'Gee, James, High Street,	do.
M'Gee, Samuel Mackey, Clifton Park Avenue,	do.
*MacIlwaine, Mrs. Jane (Representatives of), Ulsterville,	do.
*MacIlwaine, John H., Brandon Villa, Strandtown,	do.
MacLaine, Alexander, J.P., Queen's Elms,	do.
M'Neill, George Martin, Beechleigh, Windsor,	do.
Neill, John R., Roseville, Windsor,	do.
Patterson, David C., Craigavad.	
Patterson, Edward Forbes, Holywood.	

Patterson, Mrs. M. E., Ardmore Terrace, Holywood.
Patterson, Richard, J.P., Kilmore, Holywood.
*Patterson, Robert Lloyd, J.P., F.L.S., Croft House, Holywood.
Patterson, William H., M.R.I.A., Garranard, Strandtown, Belfast.
Patterson, William R., College Park East, Belfast.
Pim, Edward W., Elmwood Trrace, do.
*Pirrie, John M., M.D. (Representatives of), do.
Porter, Drummond, Botanic Avenue, do.
Purdon, Thomas Henry, M.D., Wellington Place, do.
Purser, Professor John, M.A., M.R.I.A., Queen's College, do.

Rea, John Henry, M.D., Great Victoria Street, do.
Riddel, William, J.P., Beechmount, do.
Ritchie, William B., M.D., J.P., The Grove, do.
Robertson, William, J.P., Netherleigh, Strandtown, do.
Robinson, John, St. James' Crescent, do.
Rowan, John, York Street, do.

Shillington, Thomas Foulkes, Castleton Park, do.
Simms, Felix Booth, Prospect Terrace, do.
Sinclair, Thomas, M.A., J.P., Hopefield, do.
Smith, John, Castleton Terrace, do.
Smith, Travers, Sandymount, do.
Smyth, John, Jun., M.A., C.E., Milltown, Banbridge.
Steen, Robert, Ph.D., Academical Institution, Belfast.
Suffern, John, Windsor, do.
Suffern, William (Representatives of), do.
Swanston, William, F.G.S., Cliftonville Avenue, do.

*Tennent, Robert (Representatives of), Rushpark, do.
*Tennent, Robert James, J.P., D.L. (Representatives of), Rushpark, Belfast.
Thomson, Charles, College Gardens, Belfast.
*Thompson, James, J P., Macedon, Whiteabbey.
*Thompson, Nathaniel (Representatives of).

Thompson, Robert, J.P. (Representatives of, Fortwilliam Park, Belfast.
*Thompson, William (Representatives of), Belfast.
Torrens, Mrs. Sarah H., Edenmore, Whiteabbey.
*Turnley, John (Representatives of), Belfast.

Valentine, G. F., The Moat, Strandtown, do.
Valentine, James W., Cromwell Terrace, do.

Walkington, D. B., Thornhill, Malone.
Walkington, Thomas R., Laurel Lodge, Strandtown, Belfast.
Wallace, James, Ulster Bank, do.
Ward, Francis D., J.P., Clonaver, Strandtown, do.
Ward, Isaac W., Colin View Terrace, do.
Wilson, James, Old Forge, Dunmurry.
Wilson, John K., Marlborough Park, Belfast.
*Wilson, Robert M., Dublin.
Workman, Charles, M.D., Newton Terrace, Glasgow.
Workman, Francis, College Gardens, Belfast.
Workman, John, J.P., Windsor, do.
Workman, Rev. Robert, Glastry, Kirkcubbin.
Workman, Rev. Robert, Newtownbreda, Belfast.
*Workman, Thomas, J.P., Craigdarragh, do.
Workman, William. Nottinghill, do.
Wright, Joseph, F.G.S., York Street, do.

Young, Robert, C.E., Rathvarna, Belfast.
*Young, Robert Magill, B.A., Ardgreenan, do.

HONORARY ASSOCIATES.

Robinson, Hugh, Clive Villas, Belfast.
Tate, Professor Ralph, F.G.S., F.L.S., Adelaide, South Australia.

ANNUAL GUINEA SUBSCRIBERS.

Bruce, James, J.P., D.L., Thorndale House, Belfast.
Carr, James, Rathowen, Windsor, do.
Corry, Sir James Porter, Bart., J.P., M.P., Dunraven, Windsor, Belfast.
Craig, James, J.P., Craigavon, Strandtown.
Dunville, Robert G., J.P., D.L., Redburne, Holywood.
Glass, James, Carradarragh, Windsor, Belfast.
Graham, O. B., J.P., Larchfield, Lisburn.
Lowenthal, J., Ashley Avenue, Belfast.
Lynn, William H., C.E., R.H.A., Crumlin Terrace, do.
Marsh, John, Glenlyon, Holywood.
Matier, Henry, J.P., Dunlambert, Fortwilliam, Belfast.
Milligan, Seaton Forrest, Royal Terrace, do.
Mulholland, J. R. T., J.P., Northumberland Street, do.
Murray, Robert, Corporation Street, do.
M'Auliffe, George, J.P., Southbush, Greenisland.
Oakman, Nicholas, Prospect Terrace, Belfast.
Pim, Joshua, Slieve-na-Failthe, Whiteabbey.
Pring, Richard W., Firmount, Fortwilliam Park, Belfast.
Reade, Robert H., Wilmont, Dunmurry.
Redfern, Professor Peter, M.D., F.R.C.S.L., Lower Crescent, Belfast.
Rogers, John, Windsor Avenue, Belfast.
Ross, William A., The Ivies, Craigavad.
Stannus, A. C., Greenisland.
Taylor, Sir David, J.P., Bertha, Windsor, Belfast.
Taylor, John Arnott, M.A., Drum House, Dunmurry.
Tate, Alexander, C.E., Longwood, Whitehouse.
Watt, R., C.E., Victoria Street, Belfast.
Webb, Richard T., Greenisland.
Wolff, G. W., The Den, Strandtown, Belfast.
Young, Samuel, Huntly Villas, Derryvolgie Avenue, do.

LIST OF BOOKS RECEIVED DURING THE YEAR.

ADELAIDE.—Transactions, Proceedings and Report of the Royal Society of South Australia, 1885. *The Society.*

BERLIN.—Verhandlungen der Gesellschaft für Erdkunde. Vol. 12, nos. 4, 5, 6, 7, 8, 9, 10, 1885. Vol. 13, nos. 1, 2, 3, 4, 1886. *The Society.*

BOLOGNA.—Rendiconto delle sessioni delle, R. Accademia della Scienze, 1884-85. *The Society.*

BOSTON, U. S. A.—Proceedings of the Boston Society of Natural History. Vols. 22 and 23, 1884-85. *The Society.*

Science Observer. Vol. 4, 47, no. 11. *The Editor.*

BREMEN.—Abhandlungen vom Naturwissenchaftlichen Vereine. Vol. 9, part 2, 1885; part 3, 1886. *The Society.*

BRESLAU.—Zeitschrift für Entomologie, (new series), part 10, 1885. *The Society.*

BRIGHTON.—Inaugural Addresses, Brighton and Sussex Natural History Society, 1884-85. *The Society.*

Annual Report of the Brighton and Sussex Natural History Society, 1885. *The Society.*

BRUSSELS.—Bulletin de la Société Royale de Botanique de Belgique. Vol. 24, part 1, 1885. *The Society.*

Comptes-Rendu de la Société Entomologique, 3rd series, nos. 57 to 72, 1885. *The Society.*

Comptes-Rendu de la Société Royale de Botanique de Belgique. Vol. 24, part 1, 1885. *The Society.*

BRUSSELS—*Continued.*

Annales de la Société Malacologique de Belgique. Vol. 13, 1878; 14, 1879; 15, 1880; 18, 1883; 19, 1884. Proces Verbaux des Sèances. Vol. 14, 1885.
The Society.

BUENOS AYRES.—Academia Nacional de Ciencias, Actas. Vol. 5, part 2, 1884; Boletin, Vol. 8, parts 2 and 3, 1885.
The Society.

CALCUTTA.—Geological Survey of India, (Palaeontologica Indica), series 4, vol. 1; series 10, vol. 4; series 10, vol. 3, parts 7 and 8; series 13, part 4, fas. 5; series 13, vols. 1 and 5; series 14, vols. 1 and 3, 1885. Records vol. 18, parts 2, 3 and 4; records vol. 19, parts 1 and 2; Memoirs, vol. 21, parts 3 and 4. *The Survey.*

CAMBRIDGE, U. S. A.—Bulletin of the Museum of Comparative Zoology. Vol. 11, no. 11, 1885; vol. 12, no. 1, 2, 3, 4, 1886; Annual Report, 1884-85. *The Society.*

CARDIFF.—Report and Transactions of the Naturalists' Society. Vol. 16, 1884-85. *The Society.*

CORDOBA.—Boletin de la Academia Nacional de Ciencias. Actas vol. 5, part 1, 1884; vol. 7, part 4, 1885. *The Society.*

CHRISTIANIA.—Forehandlinger i Videnakabs Selskabet, for 1884.
Do. Do. 1885.
The Society.

DANZIG.—Schriften der Naturforschenden Gesellschaft. New Series, 6th book, parts 2, 3, 1885-86. *The Society.*

DUBLIN.—Royal Dublin Society's Transactions. Vol. 3, series 2, parts 4, 5, 6, 7, 8, 9, 10, 1884-85; Proceedings, vol. 4, parts 5, 6, 7, 8, 9, 1884-85; Proceedings, vol. 5, parts 1, 2, 1886. *The Society.*

EDINBURGH.—Transactions and Proceedings of the Botanical Society. Vol. 15, part 2, 1885; vol. 16, part 1, and 2, 1886. *The Society.*

EMDEN.—Naturforschenden Gesellschaft, 69th year, 1883-84; 70th year, 1884-85. *The Society.*

ESSEX.—Transactions Essex Field Club. Vol. 4, part 1, 1885. Journal of Proceedings, 1885; Appendix. *The Society.*

FLORENCE.—Bulletino della Societa Entomologica Italiana, Trimestri, 1, 2, 3, 4, 1884; Statuto, 1885. *The Society.*

GENOA.—Giornale della Societa di Letture e Conversazioni Scientifiche. Anno 9, (*Fasc.*), 1, 2, 3, 4, 5, 6, 1885; anno 9, 2° Semestre, (*Fasc.*), 6, 1885; supplement to (*Fasc.*)s anno 9, 1° Semestre, (*Fasc.*), 1, 2, 1886.

GIESSEN.—Oberhessischen Gesslleschaft for Natur-und Heilkunde, 23 vol, 1884. *The Society.*

GLASGOW.—Proceedings and Transactions of the Natural History Society. Vol. 5, part 3, 1882-83; vol., 1, (N.S.) part 2, 1883-4-5. Index, vols. 1 to 5, 1 1884 and 2 1886. *The Society.*

Proceedings Philosophical Society. Vol. 16. *The Society.*

KOLOZSVART.—Magyar Novenytani Lapok. (8 évfolyam), 1884, and (9 évfolyam), 1885. *The Society.*

LAUSANNE.—Bulletin de la Société Vaudoise des Sciences Naturelles. 2nd series, vol. 21, no. 92, 1885 and no. 93, 1886. *The Society.*

LEIPZIG.—Sitzungsberichte der Naturforschenden Gesellschaft, 11th year, 1885. *The Society.*

LIVERPOOL.—Proceedings of the Literary and Philosophical Society. Vol. 38, for 1883 and 1884. *The Society.*

LONDON.—Journal of the Royal Microscopical Society. Series 2, vol. 5, parts 1, 2, 3, 4, 5, and 6, 1885; series 2 vol. 6, parts 1 and 2, 1886; 49a index. *The Society.*

LONDON—*Continued.*

Zoological Society's Proceedings. Parts 1, 2, 3, and 4, 1885. *The Society.*

Illustrations of British Fungi, by M. C. Cooke. Nos. 31 to 41, 1885. *Lord Clermont.*

On some recently discovered Insecta from Carboniferous and Silurian Rocks, by Herbert Goss, F.L.S. *The Author.*

Ray Society, Allman's Freshwater Polyzoa, 1856; Cetacea 1866; Allman's Hydroids, part 1, 1871; Allman's Hydroids, part 2, 1872; M'Intosh's Monograph of the British Annelids, part 1, The Nemerteans, 1873; part 2, The Nemerteans, continued, 1874. *Lord Clermont.*

MANCHESTER.—Transactions of the Manchester Geological Society. Sessions 1885-86; parts 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 1885-86. *The Society.*

MELBOURNE.—Proceedings of the Victorian Branch of Geographical Society, 1886. *The Society.*

MOSCOW.—Bulletin de la Société Imperiale Des Naturalistes. No. 4, 1884. *The Society.*

NEW YORK.—Bulletin of the American Geographical Society. Nos. 1 and 2, 1885. *The Society.*

Annals of the New York Academy of Sciences. Vol. 3, parts 7, 8, 1885.

Transactions of same. Vol. 3, 1885-86; vol. 5, no. 1, 1885-86. *The Society.*

ODESSA.—Memoirs of the New Russian Society of Naturalists. Vol. 9, parts 1, 2, 3, 1884. *The Society.*

OSNABRÜCK.—Sechster Jahresbericht des Naturwissenschaftlichen Vereins, 1883-84, 1885. *The Society.*

PADUA.—Bulletin, Societa Veneto Trentina di Scienze Naturali. Vol. 3, no. 3, 1885; Atti, vol. 9, *(Fasc.)* 2, 1885. *The Society.*

PHILADELPHIA (U.S.A.)—Proceedings of the Academy of Natural Sciences. Nos. 1, 2, 3, 4, 5, 6, 1862; nos. 1, 2, 3, 4, 5, 1865; nos. 1, 2, 1881; no. 3, 1882; part 1, 2, 1885. *The Society.*

PISA.—Atti Della Societa Toscana di Scienze Naturali Processa Verbali. Vols. 4 and 5, 1885-87. *The Society.*

RICHMOND (Indiana, U.S.A.)—Bulletin of the Brookville Society of Natural History, 1885. *The Society.*

RIO DE JANEIRO.—Conference Faite au Museum National, 1885. *The Society.*

ROME.—Atti della Realle Accademia dei Lincei. Series 4, vol. 1, parts 10 to 18, and 20 to 26; 27, 28, 1885.
Do. Vol. 2, (*Fasc.*), 1, 3, 5, 6, 7, 8, 9, 10, 1886.
Osservazioni Meteorologiche, 1885. *The Society.*

SONDERSHAUSEN—Irmischia Korrespondenzblatt des Botanischen Vereins fur Thuringer. Parts 4, 5, 6, 7, 8, 9, 10, 11, 12, 1885. *The Society.*

STOCKHOLM.—Das Gehororgan der Wirbelthiere, von Gustaf Retzius. Vol. 2, 1884. *The Author.*
Academia Royale des Sciences Handlunger, (Memoirs). Vols. 18, 19, 1880, parts 1, 2, 1881.
Bihang, (Supplement to the Memoirs). Vol. 6, parts 1, 2; vol. 7, parts 1, 2, 1885; vol. 8, parts 1, 2, 1880-84.
Ofversigt, (Bulletin), 1881, 1882, 1883.
Lefnadsteekningar, (Biographies) of Members. Vol. 2, part 2, 1883. *The Society.*

STUGGTART.—Europaische Fauna oder Verzeichnung der Wirbelthiere Europa's. Vol. 1 and 2; by Dr. Heinrich Schinz, 1840. *Lord Clermont.*

TORONTO.—Proceedings of the Canadian Institute. Vol. 2, part 2, 1884 ; and vol.3, part 3, 1886. *The Society.*

VENICE.—Notarisia Commentarium Phycologium. Vol. 1, nos. 1 and 2, 1886. *The Society.*

VIENNA.—Verhandlungen der Kaiserlich Königlichen Zoologischbotanischen Gesellschaft. Vol. 35, 1st half year ; vol. 35, 2nd half year, 1885. *The Society.*

Verhandlungen der Kaiserlich Königlichen Geologischen Reichsanstalt. No. 1 to 18, 1885 ; no. 1 to 16, 1886. *The Society.*

Annalen des Kaiserlich Königlichen Naturhistorischen Hofmuseums. Band 1, nos. 1, 2, 1886. *The Society.*

Mittheilungen des Ornithologischen Vereins. Nos. 1 to 18, and 20 to 32, 1885 ; 1 no. 1886 ; Section für Geflugelzucht, 2nd year, nos. 1 to 26. *The Society.*

WARWICK.—Annual Report of the Warwickshire Natural History and Archaeological Society, 1884-85. *The Society.*

Proceedings of the Warwickshire Naturalists' and Archaeologists' Field Club, 1884. *The Club.*

WASHINGTON.—Report of the Department of Agriculture, 1884. *The Department.*

Geological Survey. 4th Annual Report, 1882-83. *The Survey.*

Smithsonian Contributions to Knowledge. Vols. 24 and 25, 1885 ; Annual Report, 1883. *The Society.*

Bureau of Ethnology. 2nd Annual Report, 1880, 1881, 1883 ; 3rd Annual Report, 1881, 1882, 1884. *The Society.*

ZURICH.—Vierteljahrschrift der Naturforschenden Gesellschaft. 26th year, 4 parts, 1881 ; 27th year, 1, 2, 3 and 4 parts, 1882 ; 28th year, 1, 2, 3 and 4 parts, 1883 ; 29th year, 1, 2, 3 and 4 parts, 1884. *The Society.*